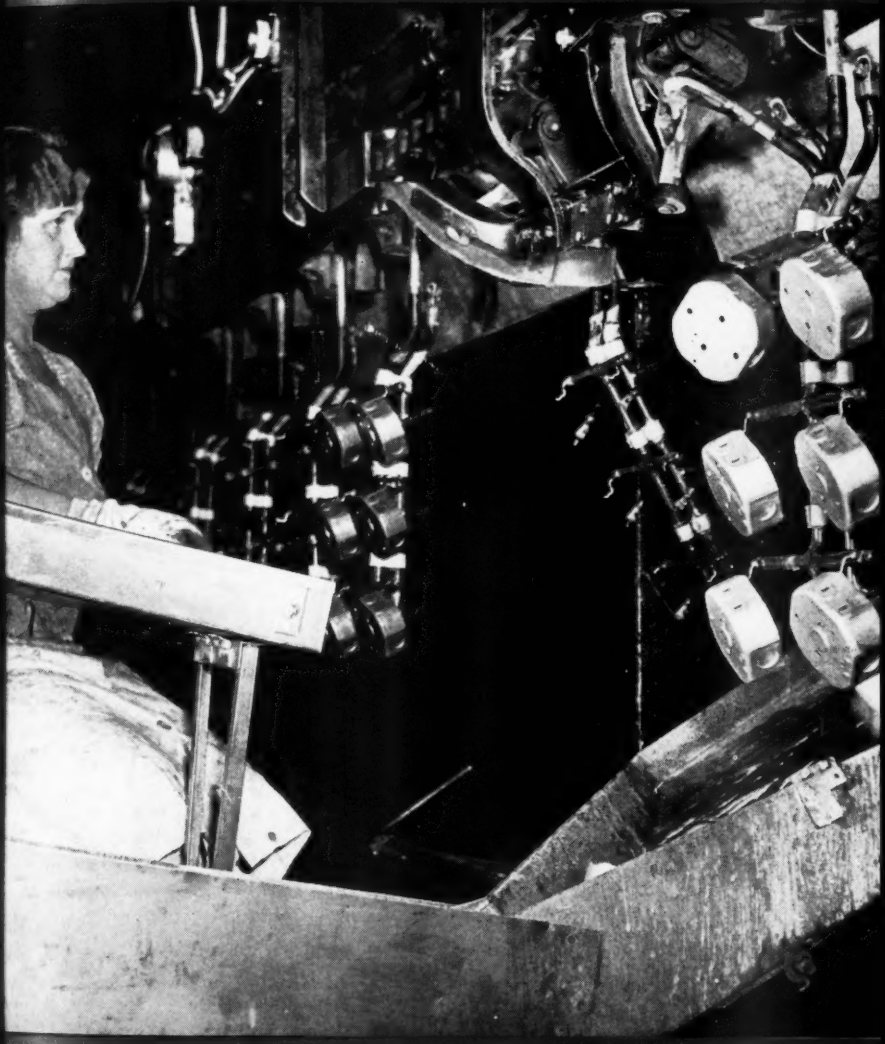
E. M. Baker

The Monthly Review

AMERICAN ELECTROPLATER'S SOCIETY



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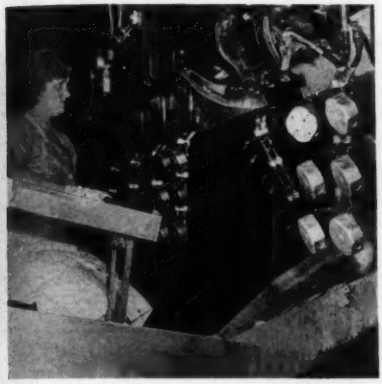

THE COVER

"Automatic Bright Zinc Plating Machine Installation at General Electric Co., Bridgeport, Conn. On this machine one operator loads 1,700 pieces per hour. Cut shows parts being unloaded automatically."

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Editorial

It has been very interesting to sit in the Editor's chair for one or two issues of the MONTHLY REVIEW as it is particularly illuminating to find out the many functions of the American Electroplaters' Society. To most Members, the A.E.S. consists only of local meetings, conventions, the MONTHLY REVIEW and the Proceedings. This same opinion was held by the near Editor for many years. However, there are many hidden functions of the Society which are not apparent to the layman and do not show up until you are familiar with the intricacies of the work.

First of all, the Proceedings which we all get as a part of our membership dues are considered a valuable source of information by Laboratories, Institutions, Colleges, Libraries, etc. all over the country. The list of people who order Proceedings is an excellent indication of the general acceptance of this volume throughout the country. It is only hoped that all of the Members appreciate its value as much as the people who send in special orders for it.

The A.E.S. is also considered a source of information on the peculiar problems of the plating field. We make no claim that all inquiries are directed to the Society but the Editor has to answer two or three inquiries a week for specific information. These requests are received from Research Bureaus, Doctors, Lawyers, etc. on questions where they require an expert opinion on a subject that is strange to them.

Many Members of the Society are interested enough in its operation to write to the Editor. Some of these letters are critical but in the majority of cases it is constructive criticism which receives careful consideration. Other letters are suggestions and modifications of details which are adopted wherever practical. Occasionally we are very gratified to receive letters of commendation on our efforts. All of these letters are welcome and are considered an indication of the interest of the Members.

If we could continue to grow and broaden ourselves as a Society to the mutual help of all the Members, there will be no question but what we will survive the present day conditions which have put a serious burden on our industry.

E. T. CANDEE.

"Recovery of Nickel from Obsolete Nickel Plating Solution"

*By WALTER L. PINNER**
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ACCORDING to data compiled by the International Nickel Company, there are, in the United States, approximately one million pounds of nickel metal existing as nickel plating salts in solution. The nickel plating solutions are, for the most part, lying idle and may represent to their possessors a liability in that storage space for them is being used which could, and, in a number of instances, must be used for direct war production. Furthermore, the million pounds of nickel contained is badly needed by the Government for use in alloy steels, it being no more evident to anyone than to the Plating Industry that nickel is scarce. Considering the various states through which this Industry passed since March, 1940, it is scarcely necessary to elaborate on the foregoing statement.

Through the efforts of the International Nickel Company and the Houdaille-Hershey Corporation, a pilot plant recovery process has been effected on nineteen hundred (1900) gallons of nickel plating solution and it is the purpose of this article to present analytical data gathered while recovering the nickel as a ferro-nickel alloy. It should be pointed out that this particular method of recovery will undoubtedly not be suitable for all plants possessing nickel solution. Some of these plants have, by this time, completely dismantled their plating departments and in some instances have loaned or rented essential parts, particularly generators. Other plants are now using the floor space for essential war production. In all such instances, the recovery of nickel by electrolysis is now fairly well impossible of accomplishment. This very situation is true of one Division of the Houdaille-Hershey Corporation.

It is believed, however, that the recovery of nickel as a ferro-nickel alloy is possible of accomplishment in a large number of

cases more easily and economically than by other methods. Obviously, however, with the existing situation, the recovery by this particular process could hardly be made manadtory.

Data from which recovery costs can be computed will be given, although it would be both unwise and impossible to definitely set a specific recovery cost because of differences in power cost, labor cost, and other intangible items that may enter the picture from one locality to another, or even from one plant to another, in the same locality. Therefore, this article will be one containing technical information on the process of nickel recovery so that every plant may have it available for such value as it may possess.

Various means may be used for recovering nickel from plating baths. The author, in conference with Mr. McKay and Dr. Wesley, of International Nickel Company, considered various methods, finally adopting the "electro-refining" of a ferro-nickel alloy. It may be well to briefly discuss, here, the other methods considered. First, and most simple, would be to merely ship the solutions in tank cars to a refinery. This proposition was rejected on the basis of high transportation costs, plus the fact that it would still be unrefined nickel solution at its destination. As a second alternative, evaporation and crystallization of nickel sulphate, nickel chloride and boric acid was considered. Such a process would involve a cost for steam, a cost for drying and packaging, the latter two being operations for which few plants are equipped, and none well equipped. Finally, the packaged material would still be nickel salts, on which money would have to be spent to make it suitable for use in steel manufacture.

This method, however, has advantages where it is impracticable to carry out electrolytic operations due to local conditions, such as removal of equipment, including generators, or lack of space. It has been used by one large company, and by their system a useable product was obtained.

This system employed a gas heated drum with a scraper, the solution being constantly sprayed on the drum and the dry salt removed by the scraper. The product contained approximately three molecules of water and was ready for roasting to nickel oxide, which can be used in steel making.

A third process considered was the precipitation of nickel carbonate using soda ash. This process would involve a chemical cost, plus the necessity for equipment which, it is safe to say, is unavailable in the size required for filtration, washing and drying of the product. Further the nickel carbonate would then have to be calcined to nickel oxide in order to be usable. Still another process involved the cementation of the nickel on powdered iron and this was rejected on the basis of a high cost for the iron powder plus a lack of facilities for handling the product, as in the case of the carbonate precipitate.

The electro refining of substantially pure nickel, using insoluble, for example, lead, anodes was discarded on the basis of a high power cost and also for cost of chemicals required to adjust a constantly decreasing pH so as to maintain good cathode efficiency. Futhermore, in such a process the inevitable evolution of chlorine gas, resulting from the breakdown of the chlorides in the solution, would create a dangerous, as well as a damaging situation. The chlorine fumes produced would be very corrosive in their action on all equipment in the department. Laboratory work by Dr. Wesley showed the voltage required with insoluble anodes to be 2.48 times that required with soluble anodes. The power cost would obviously be in the same ratio. A consideration of all costs for this process, as compared with the one adopted, definitely determined the course used, with a wide margin.

The recovery of the nickel, as a ferro-nickel alloy, consists briefly in electro-refining the nickel by plating with iron or steel anodes. During the process, iron dissolves from the anodes, and, except for the very first short stage, plates out with the nickel as an iron nickel alloy. As the process continues, the bath becomes richer in iron and more depleted in nickel until at the end it is essentially an iron plating solution with nickel as an impurity. During electrolysis the pH changes only moderately, remaining essentially within a good nickel plating operating range. The specific pH behavior is apparently a function of the cathode current density used.

The anodes dissolve completely and are replaced from time to time with new ones. The original cathode starting sheet may

advisedly consist of any ferrous sheet metal so that the conglomerate cathode obtained from the recovery may be directly used for steel manufacture. Nickel may be used for starting sheet, although this would be inadvisable inasmuch as pure nickel is saleable and usable as such more advantageously than the impure product which results from the process.

The cathode starting sheet should be flat and so spaced in the plating tank as to avoid great differences in current density over its entire area. Undoubtedly the relative efficiency of plating nickel and iron simultaneously is a function of current density which should be such as to favor a high nickel alloy. According to previously developed data, Wesley found a cathode current density of 30 amps per square foot to be optimum over the most part of the process. It is inevitable that, with this average current density, the edges of the cathode sheets will receive a higher amount resulting in considerable treeing of the deposit. This is of no consequence, however, as periodically the cathodes may be raised, the nickel trees broken off and stored in suitable containers.

From the data sheet appended, and as would be expected, there is an effect of current density on the bath pH which, in turn, would be expected to affect the relative deposition potentials of nickel and iron. Thus, Wesley, in his preliminary laboratory work, operating with a bath pH of about 5.5, found it necessary to remove the last 15% of recoverable nickel at 5 amps per square foot in order to get a high nickel alloy from a bath high in iron and low in nickel. In the operation recorded here, with a pH in the neighborhood of 4.0, it was found advantageous to increase current density above 30 amps per square foot in order to accomplish a similar result.

During electrolysis, the bath temperature was maintained at 120-140°F. The solution was not stirred during plating and the cathodes were not moved. While relative cathode-solution movement might be otherwise beneficial, it was considered unwise to employ such movement due to the very tremendous amount of iron sludge present in the bath. Filtration would undoubtedly have contributed to smoother cathodes but was not used because of the desire to keep the cost of processing at a minimum. Besides, considering the purpose for which the

product is to be used, its physical properties and appearance are of no consequence.

Substantially 85% of the nickel originally present in the bath was recovered. According to Wesley's preliminary laboratory work, and as revealed by a detailed examination of the data attached, the process becomes too costly and too inefficient to attempt to recover the last 15%, which is finally scrapped or discarded. Up to the stage of the process at which about 60% of the nickel has been removed, the cathode product had the appearance of nickel. Afterward it assumed a darker appearance, much like that of an iron plate and, in fact, is known by examination of the data to be a higher iron alloy.

It is obvious to one in possession of essential knowledge of electroplating that the cathode product is of a constantly changing composition and even at any particular instant will vary in composition according to the current density used in its deposition. From one stage to another in the process the product varies from 100% nickel at its start to undoubtedly less than 50% nickel. Due to these considerations, the product is hardly subject to analysis, as such, because of the extreme difficulty in selecting, by any means, a representative sample. Therefore, the product must be solely judged on its total weight and the definitely known amounts of nickel removed from the solution which can only have gone to the cathode. Thus, if a bath of, say 1000 gallons, is positively known to contain 500 pounds of nickel at the start, and is known to contain 75 pounds of nickel at the end, then it is known that 425 pounds are contained in the cathode product. If the product has a total weight of 850 pounds then it can be stated with certainty that it has a 50% nickel and 50% iron alloy. It cannot be sampled and analyzed but it can be used in steel manufacture and the steel maker should find his 425 pounds of nickel contained in his heat of steel if he has added the 850 pounds of product furnished him. On this basis, the product should be handed the steel maker in suitable size batches so that he can use each in its entirety as he will not know the composition of any part of the batch.

It is not the intention of this paper to discuss recovery costs nor prices to be paid for the product. At the present writing the author does not know the status of this important point but ob-

viously, if the Government elects to issue instructions that the nickel in the Indusrty should be salvaged, some allowance for recovery cost, automatic loss, and price for the product per pound of nickel contained will be set.

With reference to the appended data sheet, the ampere hour readings were accurately established by an ampere hour meter. Voltage readings were made daily as recorded and the kilowatt hour values were computed from the above. It should be pointed out that these values are those delivered by the generator. As the average motor generator set, operated under these conditions would not be expected to have an electrical efficiency of over 70%, the kilowatt hours used per pound of nickel recovered should be multiplied by at least 143% to arrive at the power input to the motor. The value obtained, times the cost of power, gives its recovery cost per pound of nickel.

With further reference to the column showing kilowatt hours per pound of nickel recovered, this constantly increasing value is an indication of the efficiency of the process as affected by the changing composition of the bath. The final accumulative figure of 4.94 KWH per pound represents at least 7.1 KWH power input into the motor. This amount of power per pound of nickel recovered is the figure used with electrode spacing, anode to cathode, of 5″. The power consumption could have been less if the electrode spacing had been reduced. However, 36″ long electrodes were used and the author was unwilling to employ a closer spacing because of fears of short circuits between nickel trees and the anodes and possibilities of bending of the electrodes occurring. Such accidents might have resulted in the burning out of generators.

Columns showing ounces and cumulative pounds of nickel recovered, are gathered from the decrease in nickel contained in the plating bath by analysis, it being known that there was no other source of loss of the nickel contained.

The column designated as "Theoretical Nickel Recovered" is of academic interest only and gives a rather inaccurate estimate of the alloy composition. It is a strictly computed tabulation, assuming from Farraday's law that if all the current were used to plate nickel at 100% efficiency, the pounds tabulated would be obtained. The figures are, of course, inaccurate inasmuch as

Date	Ampere Hrs. Daily	Cumulative Amp. Hrs.	Sol'n. Anal. Oz./gal. of Ni.	Ni. Recovered Oz./Gal.	Cumulative Oz./gal. Rec'd.	Cumulative Lbs./1900 gal.	Theoretical Lbs. of Ni. possibly recovered at 100%	Ave. Approx. Current Dens.	Voltage at Generator	Cumulative KWH	Solution pH	Cumulative KWH per Lb. Ni. Recovered
7/16	Starting		9.3									
7/17	43,800	43,800	8.65	0.65	0.65	77.3	106	30	5¼	229	2.8	2.96
7/18	29,400	73,200	Chemical analysis values for these three					30	5¼		3.3	
7/20	29,400	102,600	days are thrown out because of unex-					30	5¼		2.7	
7/21	48,000	150,600	pected solution stratification and un-					45			3.0	
			certain and erroneous analytical meth-									
			ods in presence of iron.									
7/22	42,600	193,200	6.56	2.09	2.74	325	466	30	5¼	1010	3.2	3.12
7/23	43,200	236,400	5.98	.58	3.32	394	570	30	5¼	1240	3.7	3.15
7/24	40,200	276,600	5.38	.60	3.92	466	668	30	5¼	1450	4.3	3.13
7/25	43,800	320,400	5.00	.38	4.30	511	771	30	5¼	1680	4.1	3.28
7/27	22,200	342,600	4.78	.22	4.52	536	814	20	4½	1780	4.1	3.32
7/28	22,600	365,200	4.70	.08	4.60	546	880	20	4½	1881	4.9	3.44
7/29	27,000	392,200	4.26	.44	5.04	598	946	30	5¼	2023	4.8	3.38
7/30	36,000	428,200	3.92	.34	5.38	635	1030	30	5¼	2212	4.8	3.48
7/31	29,400	457,600	3.66	.26	5.64	665	1100	30	5¼	2366	4.8	3.56
8/3	56,200	513,800	3.03	.63	6.27	740	1240	45	7⅛	2786	5.1	3.76
8/4	39,600	553,400	2.64	.39	6.71	786	1330	40	7	3063	4.1	3.89
8/5	19,200	572,600	2.34	.30	6.96	822	1380	40	7	3197	4.0	3.89
8/6	29,400	602,000	2.16	.18	7.14	847	1450	40	7	3402	4.0	4.03
8/10	50,400	652,400	1.88	.28	7.42	882	1570	40	7	3755	3.9	4.26
8/11	27,600	680,000	1.70	.18	7.60	903	1635	40	7	3948	3.9	4.38
8/12	43,200	723,200	1.46	.24	7.84	931	1740	40	8¾	4326	3.8	4.64
8/13	17,400	740,600	1.37	.09	7.93	942	1782	30	8	4565	3.7	4.95

the process undoubtedly did not operate at 100% efficiency and also since iron has a different electrochemical equivalent than nickel. However, if these known sources of inaccuracy are recognized, a fair idea of the efficiency of the process can be obtained from the data.

Specifically, in this pilot plant test, the total weight of electrodeposited metal was 1621 pounds. This weight does not include the weight of the starting sheet. Therefore, the 942 pounds of nickel recovered represented 58% of the whole. For the process 1828 pounds of iron anodes were dissolved, amounting to 1.93 pounds of iron per pound of nickel recovered. The balance of the iron not contained in the product is present in the bath in solution or as a heavy iron sludge.

The cost of the iron, including that of the starting sheet, must, of course, be included in the cost of the recovery process and other expenses include incidental labor for setup, removing of nickel trees, packaging and shipping of the product.

Ordinary volumetric methods of analysis for nickel are applicable with difficulty to the bath after it accumulates a considerable amount of iron in solution. The following method was used, with dependable results. A 10 cc., sample of the bath is diluted to exactly 100 cc., in a volumetric flask. A 10 cc., aliquot portion is pipetted into a 250 cc., beaker, this amounting to a 1 cc., sample of the bath.

The sample is diluted to about 50 cc., and heated practically to boiling. A few drops of hydrogen peroxide are added, followed by a slight excess of ammonia. The precipitate formed is filtered, washed and the filtrate is retained. The precipitate is redissolved in 1:1 hydrochloric acid. This solution is heated practically to boiling and again made ammonical by the addition of ammonia to a slight excess. The mixture is again filtered and washed, the filtrate and washings being added to the original filtrate.

The filtrate is then analyzed for nickel in the usual manner by adding a few drops of 2% KI solution, followed by a few measured drops of standard $AgNO_3$, followed by a titration with standard NaCN to a clear endpoint. The amount of NaCN required to titrate the measured amount of $AgNO_3$ is subtracted from the total, and the balance is computed as that required to titrate the nickel in the sample.

The Chemistry of Chromic Acid Anodic Baths and its Application to Bath Control

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THE importance of chromic acid anodizing in the finishing of aluminum is well known. Little information is available on the chemistry of the anodic bath as its composition changes through use and the significance of these changes in controlling of the bath through measurements of pH with glass electrode instruments.

A freshly-prepared anodic bath consists of a pure chromic acid solution. The measurement of pH with a glass electrode meter gives readings such as:—

CrO_3, grams/liter	100	50	20	10	5	2	1
pH, 25°C.	0.10	0.40	0.79	1.09	1.39	1.80	2.08

These values are plotted in Fig. I. It has been shown that various types of pH meters give different readings (1), but that all the better-known commercial instruments give consistent results and may be used for control purposes if checked against chromic acid solutions of known strength. The values given in this paper were obtained with a Beckman pH meter.

As the bath is used, alumina accumulates in the solution and the pH increases, indicating that the hydrogen-ion activity has decreased. A similar effect is produced by trivalent chromium, which does not appear in significant quantity during normal operation of the bath, but may be produced in large amounts by the action of chromic acid on wooden separators or other organic matter. It is usually assumed that the compounds formed are aluminum and chromic dichromates (2, 3). Since various workers have postulated different chemical properties for these compounds, solutions in which the solute had the composition of chromic or aluminum dichromate as determined by analysis, were studied. The results given in Table I are quoted from a previous paper by the author (4).

TABLE I

CrO_3 grams/liter	Cr_2O_3 grams/liter	$Cr_2(Cr_3O_7)_3$ mole/liter	pH
214.2	59.2	0.357	0.23
107.1	29.6	0.1785	0.68
53.6	14.8	0.0892	1.04
26.8	7.4	0.0446	1.39
13.4	3.7	0.0223	1.67
6.7	1.85	0.0112	1.95
	Al_2O_3 grams/liter	$Al_2(Cr_3O_7)_3$ mole/liter	
409.2	69.6	0.682	0.18
204.6	34.8	0.341	0.92
102.3	17.4	0.1705	1.44
51.2	8.7	0.0853	1.82
25.6	4.35	0.0426	2.14
12.8	2.18	0.0213	2.43
6.4	1.09	0.0107	2.72

These results show that the dichromates are not completely inactive, but still possess considerable hydrogen-ion activity. This is particularly true of chromic dichromate. They are, therefore, neither undissociated solutes nor colloids. They behave as ionized salts, but are appreciably hydrolyzed and undergo considerable rearrangement after formation, as noted below.

Buzzard and Wilson (2) have concluded that the pH, as determined by the glass electrode, is a measure of the free chromic acid content and operating condition of the anodic bath. On this assumption, the free chromic acid content of the solutions given above may be calculated from the pH data for pure chromic acid. If the remainder of the chromic acid is assumed to be combined with the aluminum, or trivalent chromium, an apparent molar ratio, Cr^{vi}/Al^{+++} or Cr^{vi}/Cr^{+++} can be calculated, using the results given in Table I.

Chromic dichromate		Aluminum dichromate	
pH	$\frac{Cr^{vi}}{Cr^{+++}}$	pH	$\frac{Cr^{vi}}{Al^{+++}}$
0.23	1.97	0.18	2.40
0.68	2.27	0.92	2.78
1.04	2.37	1.44	2.87
1.39	2.45	1.82	2.90
1.67	2.42	2.14	2.90
1.95	2.36	2.43	2.90
		2.72	2.90

Of particular interest to the anodizer is the decrease in combining ratio, and resultant increase in chromic acid activity as the pH decreases. An investigation of this unexpected phenomenon has disclosed (4) that the effect is due to activity effects which

render the hydrogen of the chromic acid present exceptionally active in solutions low in pH and high in aluminum and trivalent chromium. The especially low pH values of chromic dichromate solutions arise from the fact that chromic salts are prone to form hydrolyzed complexes, thus:—

$$Cr_2(Cr_2O_7)_3 \rightleftarrows Cr[Cr(Cr_2O_7)_3]$$

$$2Cr[Cr(Cr_2O_7)_3] + 3H_2O \rightleftarrows 2Cr[Cr(CrO_4)_3] + 3Cr_2O_7^{=} + 6H^+$$

$$Cr[Cr(CrO_4)_3] + 3H_2O \rightleftarrows Cr[Cr\begin{matrix}(OH)_4\\CrO_4\end{matrix}] + Cr_2O_7^{=} + 2H^+$$

Such compounds have been described (3, 5), and the behavior of chromic dichromate solutions indicates that even in strongly acid solutions considerable quantities of the partially hydrolyzed products are present. Indeed, at pH 3-3.5, the basic chromate, $Cr[Cr(OH)_4CrO_4]$, precipitates in considerable quantity.

The aluminum dichromates show evidence of similar behavior, and as the pH rises to 3.2 or above, also form an insoluble compound which is probably an analogous basic chromate. A mixture of these two compounds forms the sludge sometimes observed in thoroughly exhausted anodizing baths. A more thorough discussion of the theory leading to these conclusions may be found in the paper previously mentioned (4).

As stated above, the glass-electrode pH reading does not indicate the true free chromic acid content of anodic baths which contain trivalent ions. However, the pH is a major controlling variable in anodizing (6), and therefore the adjustment of pH by the addition of chromic acid is an important control operation. A laboratory study of the addition of chromic acid to aluminum and chromic dichromate solutions gives the following results:—

Concn., Mole/Liter				pH Values			Apparent Ratio Combined $\frac{Cr^{vi}}{Al^{+++}}$
$Al_2(Cr_2O_7)_3$	Added CrO_3	Al^{+++}	Total Cr^{vi}	Obsv'd	Calc'd.	De-crease	
0.256	0	0.512	1.536	1.17	—	—	2.84
0.256	0.100	0.512	1.636	0.59	0.83	0.24	2.58
0.256	0.200	0.512	1.736	0.39	0.64	0.25	2.41
0.256	0.400	0.512	1.936	0.16	0.41	0.25	2.10
0.128	0	0.256	0.768	1.64	—	—	2.89
0.128	0.100	0.256	0.868	0.84	0.98	0.14	2.70
0.128	0.200	0.256	0.968	0.59	0.73	0.14	2.54
0.128	0.400	0.256	1.168	0.34	0.47	0.13	2.46
0.064	0	0.128	0.384	1.97	—	—	2.90
0.064	0.100	0.128	0.484	0.97	1.04	0.07	2.76
0.064	0.200	0.128	0.584	0.70	0.76	0.06	2.65
0.064	0.400	0.128	0.784	0.42	0.48	0.06	2.45

Concn., Mole/Liter				pH Values			Apparent Ratio Combined $\frac{Cr^{vi}}{Cr^{+++}}$
$Cr_2(Cr_2O_7)_3$	Added CrO_3	Cr^{+++}	Total Cr^{vi}	Obsv'd	Calc'd.	De-crease	
0.1785	0	0.357	1.071	0.68	—	—	2.27
0.1785	0.100	0.357	1.171	0.48	0.54	0.06	2.14
0.1785	0.200	0.357	1.271	0.31	0.43	0.12	1.87
0.1785	0.400	0.357	1.471	0.16	0.28	0.12	1.71
0.0892	0	0.1785	0.536	1.04	—	—	2.37
0.0892	0.100	0.1785	0.636	0.70	0.76	0.06	2.19
0.0892	0.200	0.1785	0.736	0.52	0.60	0.08	2.06
0.0892	0.400	0.1785	0.936	0.31	0.39	0.08	1.85
0.0446	0	0.0892	0.268	1.39	—	—	2.45
0.0446	0.100	0.0892	0.368	0.88	0.92	0.04	2.32
0.0446	0.200	0.0892	0.468	0.65	0.69	0.04	2.16
0.0446	0.400	0.0892	0.668	0.40	0.44	0.04	1.98

It will be seen that the chromic acid additions to baths containing trivalent ions produce a lower pH than that anticipated. The apparent combining ratio is again observed to decrease as the pH decreases, the relation being shown in Figure II. Examination of a large number of samples has shown the validity of this general relation, although erratic results have been obtained with solutions high in both alumina and trivalent chromium. It may also be mentioned that the calculated combining ratio is greatly changed by small errors in pH measurement at low pH values, and therefore the values for the ratio at pH values below 0.7 are less precise.

The result of this effect is that in solutions containing trivalent chromium and aluminum, there is a greater efficiency in the use of chromic acid which may be added for pH adjustment purposes than has hitherto been suspected. Alumina and trivalent chromium are thus alike in their influence on the chemistry of the anodic bath. Both are impurities and therefore undesirable; however, since trivalent chromium is largely an avoidable impurity, its presence represents inefficient operation. Not only does a mole of trivalent chromium represent the loss of the mole of chromic acid from which it was formed, but it will also combine with from 1.7 to 2.4 moles of additional chromic acid, depending on pH; a total loss of from 2.7 to 3.4 moles of chromic acid. Formation of trivalent chromium occurs as a result of reduction of chromic acid by wooden lattices, other organic matter, or dissolving of aluminum accidentally left in the tank. Trivalent chromium will be slowly reoxidized by continuing anodizing with reducing agents removed. Reduced solutions

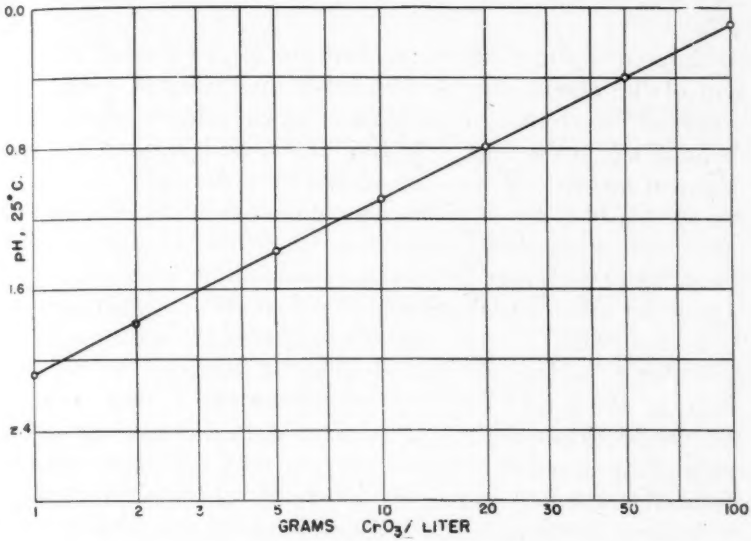

FIGURE I pH OF CHROMIC ACID SOLUTIONS.

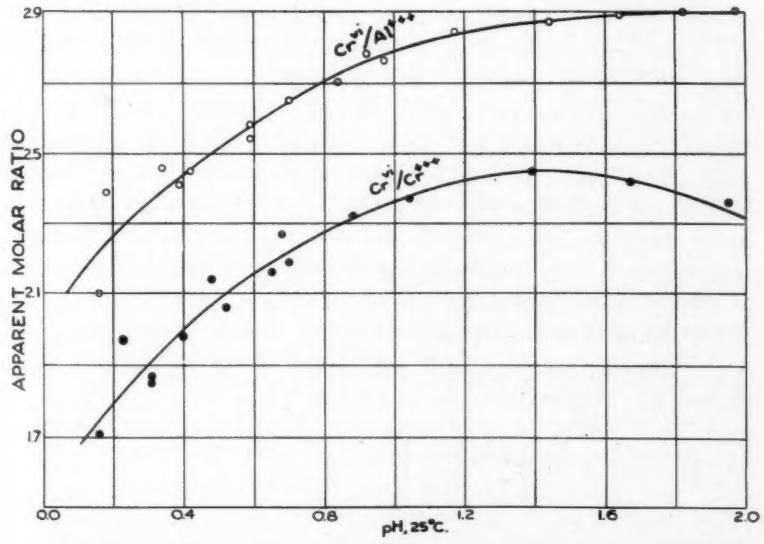

FIGURE II. VARIATION OF APPARENT RATIO OF Cr^{vi}/Cr^{+++} AND Cr^{vi}/Al^{+++} WITH pH

may also be regenerated by oxidation with lead anodes at 3-6 volts.

Alumina accumulates in the bath mainly as a result of solution of the anodic film, and in lesser quantities as a result of action of the electrolyte on aluminum, particularly pieces accidentally left in the tank. It is an unavoidable impurity and no practical method for its removal has been devised. In adjusting the pH of baths in which alumina is present, there must be taken into account the manner in which the alumina is combined, and the change in effective combination with pH. This is done by taking into account the pH-combining ratio relation. Thus, for example, from the tables above, the addition of 20 grams CrO_3 to a liter of bath containing 76.8 grams CrO_3 and 13.0 grams of Al_2O_3 (pH 1.64) will reduce the pH to 0.59, whereas addition of 20 grams CrO_3 to a liter of pure chromic acid at the same pH will reduce the pH only to 0.73. A bath may be operated indefinitely at a maintained pH, allowing the alumina to reach a limiting value as determined by the desired total CrO_3 strength and maintained pH (7). Thus, a bath containing 100 g./liter total CrO_3 and maintained at pH 0.9 will contain 15.7 g. Al_2O_3/liter, and may be maintained by periodic draw-offs as the pH increases, and replacement with chromic acid. If, for instance, in the above bath, it is desired to reduce the pH from 1.1 to 0.9, it is necessary, by application of the principles set forth in this paper, to draw off approximately 40 ml. per liter of bath, and to add 4.0 g. CrO_3 in 40 ml. solution to restore the original volume. If calculations are predicated on free chromic acid alone, the draw-off and addition would be more than half again as great, being 64 ml. and 6.4 g. CrO_3 per liter of bath, respectively. The resulting pH would be too low and some loss of efficiency and uniformity would result.

Mr. Marc Darrin of this laboratory has derived general formulas for draw-offs and additions, based on the values plotted in Figure II. These formulas are:—

$$D = V\left[1 - \frac{R_o(T_d - F_d)}{R_d(T_o - F_o)}\right]$$

$$C = .00835V\left[T_d - T_o\left(1 - \frac{D}{V}\right)\right]$$

where: D = Draw-off in gallons.
C = Chromic acid to be added, pounds.
V = Bath volume, gallons.
R_o, R_d = Apparent combining ratio at observed pH and desired pH. Values of R are plotted in the curve Cr^{vi}/Al^{+++}, figure II.
T_o, T_d = Total CrO_3, grams per liter, observed and desired. In a maintained bath, at equilibrium $T_o = T_d$, and usually = 100. The formula may then be simplified somewhat.
F_o, F_d = Free chromic acid as determined by pH. Values are given from figure I, or may be interpolated from the table.

The uncertainties caused by impurities such as trivalent chromium and alloying elements which accumulate during the continuous anodizing of alloys make these formulas subject to errors, but they serve as a guide to give values which are approximately correct.

CONCLUSIONS

The chemistry of the anodic bath has been discussed and the application to control of continuously operated baths shown. Solutions in which aluminum and trivalent chromium have accumulated have been shown to possess abnormally high hydrogen-ion activity, due both to hydrolysis of the dichromates and activity effects. Advantage may be taken of this phenomenon in calculating draw-off and acid additions during continuous operation.

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Tying In Local Branch Activities With The War Effort

J. H. DONAHUE

President Hartford Branch American Electro-Plater's Society

THE next 18 months will be critical ones for technical organizations. Those that make progress—it might almost be said those that survive—will be associations that accept the challenge to justify their existence. Programs must be practical and timely—subjects being developed either by capable speakers or in stimulating open forum discussions. Only by receiving vital information will the members feel repaid for the time and time spent in getting to and attending the meetings.

Those were some of the problems facing Hartford Branch when the program committee and board of managers met to consider plans for the meetings during the 1942-43 term.

The suggestion was made that topics for discussion be obtained by finding out what problems were confronting local manufacturers. It was realized that scant attention would be paid to letters requesting subjects for the monthly programs. The idea had to be tied in more closely with the manufacturers' own interests.

Problems could have been suggested by member platers. But wouldn't it be better to create interest also among superintendents and plant managers? The work of these executives is not closely associated with plating and finishing. Any plan that would attract their attention would have two advantages. Management would take new or greater interest in the Society. There would also be a very favorable reaction toward the platers: top executives would understand something of the nature of their problems and would also be impressed by learning that platers have the support of a national technical society.

These ideas developed into the premise that Hartford Branch could best promote its own interest by rendering some definite service to local industry. Considerable thought was devoted to perfecting a plan. This has been so favorably received that other branches may wish to adopt it.

The letter finally drafted and signed by the president of the

branch contained no suggestion that the manufacturer was doing the branch a favor by submitting topics. Instead, the letter conveys just the opposite meaning! That it was so received is shown by the reply which is typical of the reaction of local executives. To make it easy for these men to reply, a form was enclosed with a stamped addressed envelope.

The letter used by Hartford Branch:

Mr. C. B. Smith, Works Mgr.,
XYZ Manufacturing Co.,
1414 Main St.,
Hartford, Conn.
Dear Mr. Smith:

Shortages and stepped up production have put a premium on up-to-the-minute knowledge of new techniques that will further the war effort. I'd like to get your opinion about a plan for making such knowledge available to the men in your finishing department.

Our educational meetings this fall will be addressed by speakers who are experts in some specialized branch of finishing. Their subjects will be vital current problems suggested by local manufacturers.

We invite you to share in the benefits of this program.

Your finishing foreman probably has a problem or two on which he is working to develop more effective procedures. If you'll take a minute to check with him and then let us know the problem, we'll schedule it for an early meeting. Your company will not be identified, but your men (whether members or not) will be welcome to attend.

Knowing the subjects that you consider important will help us greatly in our plans to assist war production by making advanced technical information available to local industry. We'll do our best to sponsor practical, fact-packed sessions for your men.

May I have your reply soon, please? Our first meeting is September 21.

Sincerely yours,

J. H. Donahue:MDR President
enc. Return Envelope

The form enclosed with the letter:

J. H. Donahue,
The Abbott Ball Company,
Hartford, Conn.

Here are the finishing problems, Mr. Donahue, suggested as topics for the Electro-Plater's Society meetings:

1.....
2.....
3.....

Please let us know time and place of meetings at which these subjects will be discussed.

Name....Mr. C. B. Smith.....
Company....XYZ Manufacturing Co.....

It is not necessary to send many letters. Ten did the job in Hartford. Four replies were received (40%), and these contained ten problems or subjects—more than enough for a year's program.

An especially encouraging reply from a plant manager:

Thank you for your letter of September 2 calling our attention

to the Educational meetings which your branch of the Electro-Plater's Society plan to hold this fall. We believe that a movement of this sort will be of real benefit to all concerned, and we will be glad to do anything we can to assist.

We have discussed the problems which our Finishing Foreman has with him and are listing on the enclosed sheet one question which seems to have him stumped. It is possible that there are other foremen who have had this same trouble and some who may have conquered it.

If you will let us know when these meetings are to be held we will be sure that all to see of the interested personnel are promptly informed.

No A.E.S. circular was enclosed with the first letter. That would have detracted attention from the message. But a circular was enclosed with the letter sent to thank those executives that replied.

The letter of thanks:

Thanks for your splendid co-operation in suggesting three subjects as topics for talks before the Hartford Branch of the American Electro-Plater's Society.

All your subjects are of vital interest at the present time and we are confident that worthwhile programs can be built up around them.

We will certainly let you know when and where the subjects will be discussed.

In the meantime, if you are not acquainted with the objectives of the Society, I believe you will be interested in the enclosed folder which briefly outlines some of the activities.

If the reply form is signed by the plating supervisor or foreman, a letter should also be sent to the executive to whom the original letter was addressed. He'll appreciate the courtesy of being thanked for his cooperation in taking the matter up with the plating department. Such a letter also provides an opportunity to tell him that the foreman has suggested some very worthwhile subjects.

One of the interesting conclusions to be drawn from this experience is that sales principles can be as effectively applied to promoting our Society as to selling tangible materials.

A program of this type is recommended particularly for branches that may not have an extensive executive membership or acceptance by management. The work of the Society is brought to the attention of executives under the most favorable circumstances—an offer of practical help to their companies and their men.

Everybody benefits from these "request programs."

The librarian has his subjects automatically selected. He can then devote his time to securing capable speakers.

The publicity committee has a wealth of worth while ma-

terial to report. Newspapers will be found unusually cooperative not only because of the tie up with the war effort but because these activities are actually "news."

The membership committee will find prospects more receptive to an invitation to join an organization that not only knows local problems but is doing something to solve them.

All members share in the best current knowledge of vital subjects. They benefit also by being identified with an organization which by its work is commanding recognition and respect.

The officers take more pride in the Society and are inspired to do more effective work because of the definite contribution to the war effort.

The branch as a whole gains that increased prestige which springs from sponsoring programs to assist local industry.

The National Society shares in the progress of branches that increase their strength and extend their influence by undertaking a job that needs to be done—and doing it well.

Editor's Note: Mr. Donahue has offered to answer any questions that members may wish to ask about putting on such a program. Just address him at The Abbott Ball Company, Hartford, Conn.

ACTIVITIES OF THE CINCINNATI BRANCH

The Cincinnati Branch has taken another step forward. We are now members of the Technical and Scientific Societies Council of Cincinnati. The following Societies are member organizations of the Council.

American Institute of Architects
American Chemical Societies
American Institute of Electrical Engineers
American Society of Civil Engineers
American Society of Heating & Ventilating Engineers
American Society for Metals
American Society of Mechanical Engineers
American Society of Tool Engineers
American Welding Society
Engineers Club of Cincinnati
Illuminating Engineering Society
Institute of Radio Engineers
Society of American Military Engineers
American Electroplaters Society

Each member will receive a bulletin that is published weekly for 40 weeks each year, beginning the second week in September.

Every A.E.S. member in good standing is welcome and is encouraged to attend any other of the Societies' meetings. This is an exceptional opportunity to obtain information on subjects relating to all phases of industrial and csientific progress. Many of the subjects discussed at other society meetings have a direct application to YOUR work. We can think of no better way in which to gain a comprehensive knowledge of industrial trends and applications. especially in this trying period, Knowledge and industry will win the war for us.

Editors Note—THIS IS ONE WAY FOR THE MEMBERS OF THE AMERICAN ELECTROPLATERS' SOCIETY TO HELP OUT THE WAR EFFORT.

The Fundamentals of Electrochemistry and Electrodeposition

XI. Standard Electrode Potentials and Their Applications

By SAMUEL GLASSTONE
D. Sc., Ph. D.
Professor of Chemistry
The University of Oklahoma
Norman, Oklahoma

The Standard Potential

In the previous article (Part XI, MONTHLY REVIEW, September 1942) it was shown that the "reversible" or "equilibrium" potential (E) acquired by a metal when placed in a solution of its own ions at ordinary temperatures, about 20°C or 72°F, is given by the equation

$$E = E_0 + \frac{0.059}{z} \log C,$$

where E_0 is a constant for the given metal, known as its "standard potential," z is the valence of the ions of the metal in the solution, and C is the (ideal) concentration of these ions, expressed in terms of gram-ions per liter. There are two points which are immediately evident from this equation. In the first place, since the logarithm of unity is zero, it follows that the second term on the right-hand side of the equation becomes zero when the concentration of the solution is 1 gram-ion per liter. Under these conditions, therefore, E becomes equal to E_0; this means, consequently, that the standard potential (E_0) for a given metal is equal to its reversible or equilibrium potential when in contact with a solution containing 1 gram-ion per liter of the ions of that metal. This definition is strictly applicable to an "ideal" solution, and in order to be exact the standard potential should be defined in terms of a solution of unit activity, in accordance with the distinction between concentration and activity made in the previous article. As noted there, however, the difference need not concern us at present.

Effect of Concentration Changes

The second point of interest to be derived from the electrode potential equation is based on the fact that the logarithm of ten is equal to unity, i.e., log 10 = 1. Hence, if the concentration C were made equal to 10 gram-ions per liter, the electrode potential would become $E_0 + 0.059/z$. In other words, a ten-fold increase in the ionic concentration makes the electrode potential more positive to the extent of $0.059/z$ volt. If the valence (z) of the ion is two, as is the case for Cu^{++} (cupric), Ni^{++}, Cd^{++}, Zn^{++}, etc., the potential increases by 0.059/2, i.e., 0.0295 volt, when the concentration of the respective ions is increased from 1 to 10 gram-ions per liter. For ions of valence unity, such as Na^+, Cu^+ (cuprous), Ag^+ and H^+, the corresponding increase of potential is 0.059 volt. Although these figures are calculated for a change of concentration from 1 gram-ion to 10 gram-ions per liter, the results are true for *any* tenfold increase of concentration. In general, owing to the presence of the logarithmic term in the equation for the electrode potential, any ten-fold change, increase or decrease, in the concentration of the ions of the metal in the solution will result in the same alteration of potential, namely 0.059 volt for a univalent ion and 0.0295 volt for a bivalent ion at 22°C. An increase of concentration is always accompanied by an increase of potential, i.e., the potential becomes more positive or less negative, while a decrease of concentration means a decrease of potential, i.e., it becomes less positive or more negative.

Restricting our consideration for the moment to bivalent ions, it is seen that every ten-fold change of concentration alters the potential by 0.0295 volt at ordinary temperatures. A hundred-fold change of concentration will alter the potential by 2 X 0.0295, i.e., 0.059 volt, and a thousand-fold change in concentration will alter the potential by 3 X 0.0295, i.e., 0.0885 volt. It is evident therefore that unless the concentration changes are extremely large, as is the case when complex ions are formed, the change of potential with the concentration of bivalent ions in solution is not very great. It is true that for a univalent ion the corresponding alterations of potential are twice as large as the figures just given, but even these are not very considerable. At higher temperatures the potential changes are somewhat greater, but they are still relatively small.

Determination of Standard Potentials

It follows from the foregoing arguments, taken together with the equation for the electrode potential, that provided the concentration of the ions of a given metal in solution does not differ very greatly from 1 gram-ion per liter, the reversible potential will be in the vicinity of the standard potential for that metal. A list of such potentials would thus be of interest, and the values for a number of common metals are given in the accompanying table.

STANDARD ELECTRODE POTENTIALS at Ordinary Temperatures

Potassium (K+)	−2.92	Cobalt (Co++)	−0.28
Sodium (Na+)	−2.71	Nickel (Ni++)	−0.23
Magnesium (Mg++)	−1.55	Tin (Sn++)	−0.14
Aluminum (Al+++)	−1.33	Lead (Pb++)	−0.12
Manganese (Mn++)	−1.10	Hydrogen (H+)	0.00
Zinc (Zn++)	−0.76	Copper (Cu++)	+0.34
Chromium (Cr++)	−0.56	Copper (Cu+)	+0.52
Iron (Fe++)	−0.44	Silver (Ag+)	+0.80
Cadmium (Cd++)	−0.40	Mercury (Hg++)	+0.85

The principles employed in the determination of standard potentials is somewhat as follows. The particular metal to be studied is placed in a solution containing its own ions at a definitely known concentration (C), and the potential (E) of the resulting electrode is measured by combining it with a standard reference electrode, e.g., the calomel electrode. The procedure is quite similar to that described in Part VIII (MONTHLY REVIEW March 1942) in connection with various forms of the hydrogen electrode. Since C is known and E for the given electrode has now been determined, the standard potential (E_0) can be calculated directly from the electrode potential equation given at the beginning of this article. For precision work somewhat more involved methods are employed, but for our present purposes the outline just given is sufficient to indicate how standard potentials are obtained experimentally.

The Hydrogen Scale

It is important to call attention to the fact that in order to state the value of an electrode potential, as in the table given above, it is necessary to decide on a "zero" for the scale of potentials. The situation is quite similar to that which exists in connection with temperature recording; we decide to take

as our zero, on the Centrigade scale, the temperature of melting ice, and all temperatures above this are called positive, while temperatures below this arbitrary zero are said to be negative. With electrode potentials the scale usually employed is known as the "hydrogen scale"; according to this the zero is taken as that of a hydrogen gas electrode (see Part VIII), with the gas at a pressure of one atmosphere, in a solution of hydrogen ions at a concentration (activity) of 1 gram-ion per liter. In other words, on the basis of the hydrogen scale the standard potential of the hydrogen electrode, at atmospheric pressure, is zero, as shown in the table.

Applications of Standard Potentials

Although the standard potentials alone give an approximate indication of the reversible potential of an electrode in a solution of its simple ions, they may be used to give more precise values if required. For example, suppose we have a solution containing zinc ions at a concentration of 0.025 gram-ion per liter; the reversible potential of a zinc electrode in this solution can be calculated from the electrode potential equation, utilizing the value of -0.76 for the standard potential of zinc; thus

$$E = -0.76 + \frac{0.059}{2} \log 0.025 = -0.81 \text{ volt.}$$

The potential of the zinc electrode in the given solution will thus be -0.81 volt on the hydrogen scale. Alternatively, if the reversible potential is known by direct measurement, the ionic concentration may be calculated; for example, if a copper electrode ($E_0 = +0.34$) when placed in a solution of cupric ions, e.g., copper sulphate solution, acquires a reversible potential of +0.26 volt, the concentration C of the cupric ions is given by the relationship

$$+0.26 = +0.34 + \frac{0.059}{2} \log C,$$

$$\therefore \log C = -2.71$$

$$C = 1.95 \times 10^{-3} \text{ gram-ion per liter}$$

These are just two simple illustrations of the numerous calculations which can be made with the aid of the electrode potential equation and the table of standard electrode potentials. Further examples will be given in later articles.

Supplies and War Production

By W. D. STARR
The Lea Mfg. Co., Waterbury, Conn.

Slow deliveries of plating equipment and supplies are often charged up to "hogging" by other firms, an ornery attitude on the part of the War Production Board, or to an alcoholic influence over the supplier. But in most cases these conditions are not responsible. More often than not, the requirements were not anticipated sufficiently in advance of actual need.

Suppose a plating room requires Nickel Salts, Zinc Anodes, Nitric Acid, Ammonia, Copper Cyanide, and other items too numerous to list. If needed during November, 1942 it will be too late to place orders October 25th or even October 15th. The supplier should have the order during the first few days of October and, in the case of some items, prior to October 1st to meet W.P.B. deadlines for allocation requests.

Many equipment items and supplies can be obtained only after the USER obtains approval from W.P.B. Forms are provided for requesting allocation. For example, PD-600 is used for Copper Chemicals. Suppliers will cooperate in explaining such procedures.

When we realize that a fair distribution of critical materials require a super inventory record at Washington, we can appreciate the necessity for an accurate listing of our requirements. Further, when we consider that the demand for some items exceeds the supply, we can see that by determining our requirements far enough in advance, we will avoid waiting at the end of the line.

SENATOR PEPPER AVAILABLE FOR LECTURES

Thomas Brady Speakers Bureau, 236 West 44th Street, New York City, announces Senator Claude Pepper will make a series of lectures under their management. Interested organizations may write Thomas Brady for details of arrangements.

NEW SURFACE CONDITIONER FOR BRIGHTENING STEEL

"SURBRIGHT" a new surface conditioner for steel is announced by Hanson-Van Winkle-Munning Company at Matawan, New Jersey.

Surbright a free running powder prepared in two types for addition to hydrochloric acid and sulphuric acid pickles. Produces a bright, smut-free surface when iron and steel are pickled.

Both forms of Sunbright are freely comparable with best of existing inhibitors in acid and metal saving. However, the bright surface produced is an advantage of the Surbright Steel surface conditioner.

APPRECIATION FOR MR. KENNEDY*

As a personal friend, who knew Mr. Kennedy quite well. I wish to add a few words to the Eulogy in the August REVIEW, in effect, that in his passing the Society has suffered a great loss is an understatement.

Sometimes we hear complaints to the effect that all which might be derived from the Society in benefits educationally and otherwise are not obtained, in that connection may I point out that,

If you feel you don't get much out of your membership
Just stop and think deeply for a minute,
And, perhaps you'll agree, the chances are,
You haven't put much into it.

Truly it can be said our departed friend Kennedy put his all into his work for the Society. Then, too, he considered all true work as sacred, and, in all true work, whether hand labor, or, otherwise, there is something of Divineness, apparently he felt that way, at any rate, he has left an example, which, if emulated by all of us, the resulting benefits would be difficult to estimate.

Truly he was an exponent of the following quotation:

"Any good thing that I can do, or, any kindness that I can show to anyone I shall do it now, I shall neither defer nor neglect it, for I shall not pass this way again."

He also exemplified the philosophy which consists in not wanting the things one can't get.

A few years ago, as some of you will recall, for one of our Annual Educational Sessions and Dinner Dance Mr. Kennedy had promised us a complete Los Angeles Branch Issue of the REVIEW, which he did not carry out, however, and in case some of you have failed to notice it, the August issue of the REVIEW, except for one article, is an all Los Angeles Branch number, whether or not he had anything to do with its set-up is immaterial, the fact remains that it should be an impressive co-incident to all of us.

In commemoration of and to his memory I suggest we all respectfully stand for one minute.

ERNEST LAMOREUX.

*Read by Mr. Lamoureux at September meeting of the Los Angeles Branch.

A. KENNETH GRAHAM

We have just received word that Dr. A. Kenneth Graham has been called by the War Production Board and has closed his private consulting practice, with headquarters at Jenkintown, Pa., for the duration. He is now Chief of the Non-Metals and Industry Section of the Conservation and Substitution Branch of the Conservation Division of the War Production Board. This Section advises on conservation and substitution where it applies to industry and non-metallic raw materials. This also includes electroplating applications. Dr. Graham. because of his chemical engineering and plating background, is well qualified for this assignment.

Mr. George B. Hogaboom, who has been with the War Production Board for almost a year, is now associated with Dr. Graham for the third time since the last war. They met the first time while employed by the Scovill Manufacturing Co., Waterbury, Connecticut in 1919. They were together again from 1926 to 1928 while working for the Hanson-Van Winkle-Munning Co. in Matawan, N. J. It is fortunate that men with their experience in the plating industry are available to assist in the solution of the many unusual plating problems arising from the war.

We wish them both success in their endeavors. The industry is proud of the sacrifices they have made in giving up their normal pursuits to assist in the war effort.

RESEARCH COMMITTEE

It may be interesting to the Members of the Society to learn of some of the problems which the Research Committee had to meet in laying out the present Research Program and the way in which these problems were settled. It has often happened that after a Research Program is laid out people are critical as they find a detail of particular importance to themselves has been omitted. The Committee has to approach the problem from an overall broad point of view and unfortunately must of necessity omit certain details.

The problem of thickness of coating to be applied to the polished metals was one detail which received considerable consideration. It was realized that if very thin coatings were put over the base metal, outdoor exposure of the samples would cause failure so rapidly that a majority of all the samples would fail between inspections and all of the failures would be so rapid that no clearcut decision could be reached as to the effect of the character of the base metal. It was also felt that if heavy coatings were used, which would ordinarily be expected to give satisfactory service life in outdoor exposure, tests would progress for such a long period of time that it would take a period of years to reach results and the work would be unnecessarily drawn out.

In laying out Research Work, regardless of how much careful consideration is given to the problem, there is almost the absolute assurance that some detail will be brought out by the preliminary results which will necessitate further work and it is desirable that these "loopholes" be found as quickly as possible so that further samples could be prepared and exposed to complete the work. After considerable consideration it was decided to use a standard nickel deposit on steel of .00075". It was also decided that a few samples would be exposed where this thickness was decreased and other samples would be exposed where this thickness was increased. Other things such as undercoatings over copper on the steel were to be included but the number of

samples of this variation from the standard deposit were only for a more thorough check and were not to be prepared in large quantities. The reason for this decision was that the exposure racks available to the Research Committee had a definite number of spaces on them and unless the Committee went to the expense of constructing new racks, they had to keep the number of samples within the limits of these racks. There was also the problem of preparing the samples since preparation of 100 samples for a research require more time than production of 100 pieces in a factory. The Research Committee has to be practical in all its decisions in order to keep time, expenses, etc. within reasonable limits.

Study of the published reports of Mr. Lux and Dr. Blum indicate the results of these various studies in the outline of the program and illustrate the way that the problem was settled.

ERRATUM

In the article on Drag-In by Joseph B. Kushner, Sept. Issue, Page 758, Equation (5E) should read

$$(5E)\quad C_x=\frac{(a+b)}{a}C_o-\left[\frac{(a+b)}{a}C_o-C_i\right]e^{-an,x/V_o}$$

instead of

$$(5E)\quad C_x=\frac{(a+b)}{a}C_o-\left[\frac{(a+b)}{sa}C_o-C_i\right]e^{-an,x/V_o}$$

as given there.

On page 762, equation (9E), a square bracket was left out immediately after the $(R^{a/b}-R)$. The corrected equation should read:

$$(9E)\quad C_x=C_1R^{\frac{xa}{b}}+C_0\left[(1-R)+\frac{a}{b-a}(R^{a/b}-R)\right]\left[\frac{1-R^{\frac{xa}{b}}}{1-R^{a/b}}\right]$$

On page 763, bottom of the page, the last symbol, V_o, should be V_1.

On page 766, top of the page, the phrase should read, "the amount of water that has evaporated is equal to V_o multiplied by one minus the depth of the solution after the run over the depth of the solution before the run."

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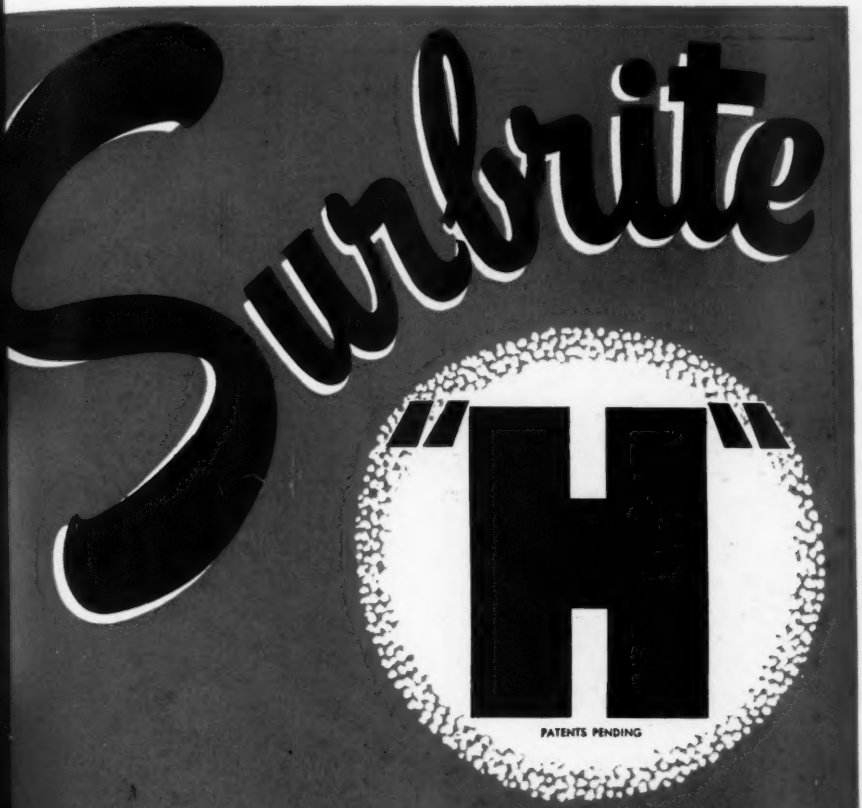

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WHEN PICKLING WITH SULPHURIC ACID, USE "SURBRITE "S"

HANSON-VAN WINKLE-MUNNING CO.
MATAWAN, NEW JERSEY

Business and Social News

BRANCH NEWS

Educational Activities

AMERICAN ELECTROPLATERS' SOCIETY

Toronto Branch held its first fall meeting on September 11th at the Royal York Hotel club room. President Boaz presided and there were 34 members present and four visitors Mr. J. F. Reisenburg of Montreal Branch, Messrs MacFarland and Clark of the Canada Cycle and Mike Novack who filled out an application for membership.

Secretary Harris was busy with a lot of piled up correspondence while Tom Boaz was figuring out the transportation to Niagara Falls, where Toronto Branch will meet with Rochester and Buffalo Branches in a joint session October 24th.

This was followed by a talk by Mr. John Acheson who gave full details of the trip, stating that the three Branches were going into this wholeheartedly and it was sure to be a great success.

President Boaz then introduced Messrs J. Acheson, J. S. Cairns, and J. J. Fitzsimmons as ten minute speakers of the evening, stating this tip was taken from some of the other Branches with apparent success.

Mr. Acheson spoke on "Good Housekeeping in the Plating Room."

J. S. Cairns spoke on "Under the Surface of Cold Rolled Steel."

J. J. Fitzsimmons spoke on "Boiling Cleaners" and stated it was poor economy to add fresh cleaner to an old and dirty solution.

The members showing appreciation with a hearty vote of thanks to the three speakers.

The plating of Plastics then came up with Mr. Reisenburg entering into the discussion.

It was reported that 4 of our members had joined the armed forces and will be carried on the Branch books until their return. The names are Art Severs, Alex Acheson, Rennie and Teach. Regrets were expressed by the death of W. J. R. Kennedy, Supreme Secretary and James Brady of Toronto Branch.

The meeting adjourned at 10:50 P.M.

J. S. CAIRNS, *Secy.*

Chicago Branch held its regular monthly meeting on Friday September 11, 1942 at the Atlantic Hotel.

First Vice President R. J. Hazucha presided and all other officers were present.

An invitation from the Electro Chemical Society regarding their convention to be held Oct. 7th to 10th at Detroit read and placed on file.

Mr. H. F. Anderson was elected to Associate membership.

A motion was made and seconded that Chicago Branch hold their annual Educational session and Banquet on Saturday, Jan. 23, 1943.

Mr. C. M. Iwen acted as guest librarian and appointed the following members as a board of experts to help answer some of the questions found in the question box, Mr. W. J. Erskine, O. Weickmann, V. E. VanStone, and C. Clindinin.

The guest speaker of the evening was Dr. O. M. Morgan of the Allied Chemical & Dye Corp. who spoke on "The Evaluation of a Surface Active

KEEP THEM TURNING

In times of peace, many Stortswelded tanks and fabrications were instrumentalities for producing some of the comforts, luxuries and nice things of life. It was our pleasure to hold down the manufacturing costs of our customers by assuring long service for their equipment, through selection of materials to resist wear and corrosion, and by making welds that would hold unfailingly. Now these vital skills and practised talents are carrying on in war production — to build well and build strong, and keep the wheels ever turning.

STORTS WELDING COMPANY

42 Stone Street Meriden, Conn.

Manufacturers of Welded Fabrications to Specification

Agent in Cleaning of Metals." This talk proved to be very timely, interesting and instructive. Dr. Morgan received a note of thanks for this fine talk.

The sound picture "Lead Mining in Southwestern Missouri" was the start of the Lead series of pictures and should prove of great interest at this particular time.

There were 70 in attendance and the meeting adjourned at 11:00 P. M.

J. W. HANLON, *Secy.*

Lancaster Branch of the A.E.S. met on September 11, 1942 at 8:00 P. M. in the Stevens Trade School. There were 29 present.

The minutes of the previous session were read and approved. The secretary reported a cash balance of $189.49 in the treasury.

At the suggestion of the secretary a motion was made and carried, to the effect that he should use his own discretion as to mailing out various items to the members.

The librarian then introduced Dr. Engl and Mr. Cohn of the Colonial Alloys Co. of Philadelphia. These two gentlemen then gave their lecture and practical demonstration on the "Electroplating and Anodizing of Aluminum and its Alloys." Mr. Cohn ably covered the subject of Electroplating Aluminum, first listing reasons advanced by previous researchers as to why it could not be done and then proceeding to demonstrate that it could be done. Briefly the aluminum is cleaned in a 50% caustic solution, rinsed in water, the caustic neutralized in a 30% nitric acid dip, rinsed in water and then immersed in the zinc preplate solution for one minute. This solution, a patent of Colonial Alloys deposits a coat of zinc on the aluminum making it suitable for plating afterwards.

Dr. Engl spoke on the different methods of anodizing; oxalic acid, chromic acid and sulphuric acid baths, listing advantages and disadvantages of all. He then proceeded to demonstrate the method patented by Colonial Alloys for producing an oxide coat on aluminum and its alloys by using alternating current and both the cathode and anode for suspending work.

An interesting discussion followed all thru the lecture and questions were answered by these men whenever possible. The meeting was closed at 10:00 P. M.

WILLIAM H. FORDNEY, *Secy.*

Newark Branch held its August meeting on the 21st., at the Hotel Robert Treat in Newark, N. J. The meeting was called to order at 8:45

Advantages of 99.925% pure Copper Anodes

1. Copper goes into solution faster, more uniformly.
2. Highest quality is deposited in shortest possible time.
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Subsidiary of Anaconda Copper Mining Co.
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P. M. with President William Bruhns presiding. Other officers present were: George Wagner, Sec'y-Treas.; Horace H. Smith, John B. Kotches and Paul A. Oldam, Board of Managers.

The minutes of the previous meeting were read and approved.

A card of thanks from the Kennedy Family and one from the Fred W. Matts Family were read and placed on file. Communications from the Heatbath Corporation, Newark Steel Drum Company and Mr. L. Hrusovsky of the Breeze Corporations were read and placed on file.

The Secretary reported in detail his trip to Springfield, Mass., where he attended the funeral services of our Executive Secretary, W. J. R. Kennedy. He next asked the members who presented papers during our last fiscal year, which have not been published in the REVIEW, for duplicate copies stating that the REVIEW needed articles for the publication of the September issue.

Mr. Byron Hogaboom acted as Librarian and conducted an informal question box.

Meeting adjourned at 10:15 P. M.

GEORGE WAGNER, *Secy.*

Newark Branch held its regular meeting on September 3, 1942 at the Robert Treat Hotel, Newark, N. J. The meeting was called to order at 8:30 P. M. with President William Bruhns presiding. Other officers present were: George Wagner, Sec'y-Treas., William T. Maguire, Librarian, Horace H. Smith and Paul A. Oldam, Board of Managers.

The minutes of the previous meeting were read and approved.

Mr. William T. Maguire, Chairman of the Program Committee reported that due to the uncertainty of the present conditions it was practically impossible to line up speakers for definite dates at this time. He suggested that we keep all the speakers names out of the Year Book, leaving it to the secretary to announce the speakers in the notices which are mailed to the members prior to each meeting.

The guest speaker for the evening was Mr. C. C. Hipkins from the Western Electric Co. and the War Production Board. Mr. Hipkins gave us a very interesting talk on "Organic Finishes and Dichromate Finishes or Chronac. This finish is applied to zinc plated steel articles. The purpose is to increase the resistance of corrosion. Mr. Hipkins exhibited numerous samples, some of which had been zinc plated only and others which had been zinc plated and chromated. The samples had been put through a corrosion test which illustrated that

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The Black Oxidized finish that penetrates Iron & Steel Surfaces

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ECONOMICAL Inexpensvie equipment with minimum procedure.

CORROSION RESISTANT Will stand a 100 hour salt spray test.

NO CHANGE IN DIMENSIONS Parts remain same size after treatment.

NON - TECHNICAL Temperatures not critical. Analytical control not necessary.

PERFECTLY UNIFORM Beautiful ebony finish maintained throughout.

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THE PURITAN MFG. CO.
Waterbury, Conn.

the resistance to corrosion of the chromated articles was increased by at least 100 per cent.

Only 24 members attended.

Meeting adjourned at 10:45 P. M.

GEORGE WAGNER, *Secy.*

Detroit Branch started the 1942-3 season with its first meeting on Friday, September 11th, at Hotel Statler, with about 150 members and friends present to listen to an all local branch program.

President J. E. Fritts introduced the first speaker of the evening, our genial Past President and new member of the Board of Managers, Walter Pinner. He reviewed the papers presented at the Grand Rapids Convention. His keen analysis and limelighting of important new developments gave our unusually busy members a quick picture of the worthwhile happenings in the industry. Many of them will be too busy to read the Convention papers in their entirety, and judging by their round of applause, they certainly appreciated Mr. Pinner's timely contribution.

The next speaker, M. J. J. Pawlik, Plating Supervisor, Continental Motors Corporation, selected for his subject "Stopping-off Carburizing and Nitriding." Mr. Pawlik came well prepared with samples illustrating the points he brought out in his discussion. He detailed the experimental work done to determine the suitable thickness of copper for Stopping-off Case Hardening by the Homocarb Method. To show that due to the poor surface condition on rough forging even thicknesses greater than .001" of copper were not sufficient to Stop-off Case Hardening when Gas Carburizing was used. On machined surfaces, however, a copper deposit of .0002 to .0005 prevents Gas Carburizing.

The speaker also brought out the

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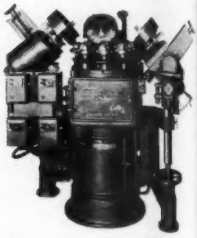

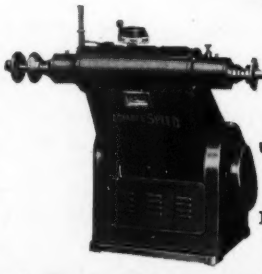

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fact that unless the proper furnace temperatures in gas analysis were maintained the copper deposit may be removed and then redeposited on the face giving the impression that the Stopped-off portions of the pieces were adequately protected. Subsequent inspection, however, revealed that the entire surface of the pieces were hardened.

Hard spots were attributed as much to porosity in the base metal as to a porous condition in the copper deposit.

Taken on the whole the paper contained a lot of practical information gleaned from actual plant operations, with the suggestion that copper may be used instead of tin for Stopping-off Nitriding.

In closing Mr. Pawlik suggested that further work was needed to determine dominant variables in the process of Stop-off Plating and subsequent Case Hardening. The large number of questions asked the speaker showed the keen interest in the subject and an appreciation by the members of information well illustrated.

The U. S. Brueau of Mines lent us a sound movie, "Nickel Highlights," which explained and showed us how nickel is mined and processed.

Our next meeting will have Mr. L. C. Tubbs, Chief Chemist, Mutual Chemical Company of America, and Mr. P. E. Roberts, President of Anotreat, Inc., to give us facts on Chromic Acid Anodizing.

WARREN I. GRIMMER, *Secy.*

Los Angeles Branch held its first meeting of the 42-43 series at the Rosslyn Hotel on September 9th.

After a good dinner including sugar for the coffee, the meeting was called to order by President E. R. Holman.

This being our first meeting we invited platers and employers with good results. Mr. Stanley Rynkoff, Seargeant-at-Arms introduced the following visitors. John Stevenson and Harold Knules of Timm Aircraft; Mr. Manual Sanz of Vultee Aircraft; B. C. Daw of LaSalco, Inc.,; C. Shaw of Calif. Electro Platers; Mr. Hamar of Douglas Aircraft,; Mr. Shull of Hughes Aircraft; Mr. Ramey and Mr. Crewse of National Products; Mr. Lease and Mr. Webb of Detroit Rex; R. Berry of Calif. Plating Co.; and Mr. J. M. Howard (chemist) Douglas Aircraft, El Segundo, Calif.

The minutes and financial reports were read and approved. A letter from Fred Maurer formerly with Hotpoint in Ontario and now serving in the armed forces, thanking the branch for the membership card. A letter from C. Savage asking for resignation was turned over to the Board of Managers.

BLACK-MAGIC

A simple, easy to operate **"One Bath process"** for blacking steel and iron.

Government approved on any contract requiring a black oxide finish.

Replaces plating at a fraction of the cost.

Mitchell-Bradford Chemical Co.
Bridgeport, Conn.
(Phone 7-1390)
Write for free portfolio.

In respect to our late Sec. Mr. W. J. R. Kennedy, Mr. Lamoureux, after reading the eulogy in the August REVIEW added the following in behalf of the Los Angles Branch.(See separate note).

Mr. Ervin Frauenhoff, first vice-president and membership chairman read the application of Mr. Fred Fergson of Square D Electric and Mr. James Bell Houston and turned them over to the Board of Managers.

The meeting was then turned over to the Librarian, Mr. ApRoberts.

Mr. Earl Coffin was asked to present the check of $50.00 to Mr. Sanz, of Vultee Aircraft Co. for his paper (Analysis of Chromic Acid Baths used for Anodizing Aluminum) which won the award at the National Convention for the best paper printed in the REVIEW last year. The presentation was accompanied with a talk of encouragement for more good papers open to everyone and the Los Angeles Branch hoped to have the honor of presenting another next year. The check was accepted with thanks by Sanz, who then gave us a talk entitled "Surface Preparation for Steel prior to Painting and Fabrication." He explained that owing to shortage of other metal that trainer ships were forced to use plywood and low carbon steel. Therefore, the research department was faced with the problem of surface treatment that would meet the requirements. Owing to lack of time Mr. Sanz did not have this talk in proper paper form but promised to have it for publication soon .Questions were asked.

Is bonderizing better than flash coating of zinc?

Ans. Yes in some cases where you can bonderize after the structure has been fabricated. Otherwise you would not be able to get a bond.

Mr. Sanz was thanked for his interesting talk by Mr. ApRoberts.

Meeting adjourned at 10:30 P. M.

C. C. MCLAREN, *Secy.*

Waterbury Branch held its opening meeting of the season, Friday, September 11th, in the Colonial Room at the Hotel Elton. President Ralph Colter in opening at 8:00 P. M., expressed the wish that this coming year will be a profitable one for the branch. The program as it has been lined up, so far, looks very interesting and we should have some worthwhile educational sessions. In addition to a speaker it is planned to show a moving picture, at each meeting, appropriate to the finishing industry. Ralph concluded his remarks by announcing the election of Murray Beebe as an asso-

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That *really* polish faster
That *really* last longer
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★ ★ The original Duart Wrinkle Enamels, with their desirable qualities of quick drying, durability, adhesion and resistance to marring, are available to manufacturers engaged in war production.

For those manufacturers who do not have the necessary priorities, we have developed alternate Duart Wrinkle Enamels which closely resemble our original Duart Wrinkle Enamels. They can be used on the same surfaces and give similar effects.

One of the chief advantages of Duart Wrinkle Enamels today is ease of application. No primer or sanding is required and they cover surface defects, such as seams and welding marks, in one coat. Even unskilled operators can apply Duart Wrinkle Enamels with uniform results.

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ciate member of the branch, then turned the meeting over to William Starr, chairman of the Branch Research Committee.

Bill was very happy to announce that two-hundred and fifty dollars had been collected from manufacturers interested in the A.E.S. Research Program and there is no doubt that the efforts of this Branch will materially aid in financing the Research Work.

Ellsworth Candee advised us that he was for the present acting Executive Secretary, until such time, as a permanent Secretary can be appointed. He finds a tremendous amount of detail involved in handling the affairs of the Society and in editing the REVIEW. All this was handled so efficiently and smoothly by Bill Kennedy, that the importance of his work for the Society has been hardly realized, until now, when he is no longer with us.

Following this brief business meeting, the Lea Manufacturing Company showed movies of the Grand Rapids Convention. The entire affair was covered very efficiently, from the first arrival of guests through the annual banquet.

Master of Ceremonies, Bob Greene, introduced the speaker of the evening, Mr. Charles E. Crowley of the Alsop Engineering Co., Mr. Crowley's talk entitled, "Flying Experiences in World War No. 1", was a real treat; as everyone present will testify. Two years in the infantry, battered by German shells, watching the airplanes darting about overhead, seemingly out of reach of all ground turmoil, gave impetus to his desire to fly. A period of intensive training in Kent, provided numerous rather startling adventures, which were followed by many hair-raising experiences in France; all told in Mr.

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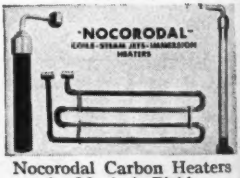

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12901 Elmwood Avenue CLEVELAND, OHIO

Facts about Metal Polishing

Setting Up the Polishing Wheel

POLISHING wheels should be coated in a room that is free from drafts. The room should be held at a temperature of approximately 80°F. to prevent rapid jelling of the glue. The hot glue solution is applied to the face of the wheel with a brush and the wheel immediately rolled in a trough of abrasive grain until it has picked up all the grain it will hold. The glue should be applied to the wheel and the whole setting-up operation carried out as quickly as possible to minimize jelling. A glue jelled during set-up is a poor adhesive for abrasive grain.

It is important that uniform pressure be applied while rolling the wheel in the grain trough. For example, it has been shown that when a 200-pound man and a 130-pound man set up wheels and each uses his maximum strength, the wheels will give different polishing performance.

Preheating Abrasive Grain and Wheels

Tests have shown that it is advisable to preheat the abrasive grain and cloth wheels to a temperature between 100° and 120°F. This will prevent the glue from jelling too rapidly during the set-up of the wheels. With preheating of the abrasive grain and wheels, the glue solution can generally be applied at a temperature of 140°F.

On the other hand, when the abrasive grain and wheels are cold or only at normal room temperatures, the rapid jelling of the glue can be retarded by heating the glue to 160°F. before using. This should be considered only a stop gap and not the best practice.

Cold wheels and grain will jell the glue rapidly, reducing its adhesive qualities as mentioned previously. There is the further effect that the abrasive grain will not penetrate as readily into the jelled glue film. Consequently the grain does not pack as well on the glue head, which means that the amount of glue relative to grain is excessive. The result is a wheel head which cuts too slowly and generates excess heat.

Other dry room conditions which are giving satisfactory results are a temperature of 75°F. and 45% relative humidity and 90°F. and 55% relative humidity.

The actual time required to dry a polishing wheel under controlled conditions is, of course, dependent mainly on the density and thickness of the abrasive-glue head and to a lesser extent on the density of the cloth or leather, etc., of the wheel itself. *If a polishing wheel is over-dried*, it becomes brittle and will have a short life because the abrasive grains will tear out of the glue sockets before they have done their maximum work. *When a wheel is under-dried*, the glue does not develop its greatest possible strength. Such a wheel will cut slowly, glaze rapidly, over-heat, and sometimes pieces will scale off.

NORTON COMPANY • **WORCESTER, MASS**

G-143

NORTON ABRASIVES

Crowley's colorful and fascinating manner. Everyone was most enthusiastic and we hope to hear Mr. Crowley again.

Beer and sandwiches were served during the evening and the meeting adjourned at 11:00 P. M.

S. L. HENN, *Secy.*

Milwaukee Branch held its 332nd regular meeting on September 4th, 1942, at the Republican Hotel. President Rodney Olsen opened the meeting at 8:15 P. M. All officers were present. The minutes of the previous meeting were read and approved.

Mr. Phil Ritzenthaler, as temporary representative of the MilwaukeeBranch A.E.S. to the Milwaukee Associated Defense Committee, gave a verbal report of the Committee's work. This Committee is composed of all the technical societies in Milwaukee and it works on problems that come up before the W.P.B. The aim of this committee is to put the problem in the most competent hands. After a discussion the members elected Mr. Ritzenthaler as permanent chairman from the Milwaukee Branch.

Mr. Robert Goodsell reported that Mr. Robert Shaffer was very ill, and Mr. William Geissman made a motion that we give Mr. Shaffer a year's subscription to Readers Digest. The motion was carried.

Mr. Charles Stoddard asked to be transferred to the Chicago Branch. His transfer was accepted.

The meeting was then turned over to the delegates to the Convention held in Grand Rapids. Mr. Phil Ritzenthaler reported on the business sessions of the convention and Mr. William Geissman gave a brief resume on the high lights of the educational sessions.

After a short discussion, the meeting adjourned at 10:15 P. M.

JAMES DURNFORD, *Secy.*

Pittsburgh Branch announces with sincere sorrow the death of its President, Mr. Stanley E. Hedden.

Mr. Hedden was a charter member of the Pittsburgh Branch and has served as Secretary-Treasurer from the Branch's inception until 1938 when he was elected President. He was Superintendent of the Enameled Metals Company of Etna and was active in his community. There is no one who has taken a more sincere interest in maintaining and building up the Pittsburgh Branch. It was only through his efforts that this branch was maintained during the depression when local interest was so low in plating. Mr. Hedden is survived by his wife and two daughters.

The Pittsburgh Branch held its first meeting this Fall Thursday, September 3rd, at the Bureau of Mines Building.

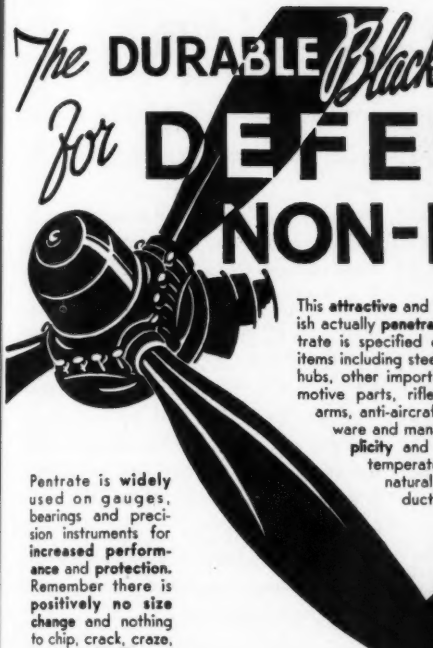
Since the death of our President, Mr. Hedden, Mr. Herbert Saylor, 1st Vice President, officiated at the meeting. A long business meeting dealing with the business of the summer and our plans for this Fall was followed by two reels of motion pictures presented by the Bureau of Mines. The pictures were "Alloy Steels" and "Diesel: The Modern Power".

It was decided to hold our meetings this year the first Thursday of each month at 8:00 P.M. at the University Club.

F. R. KELLER, *Secy.*

The DURABLE *Black* Finish for STEEL

For DEFENSE *and* NON-DEFENSE



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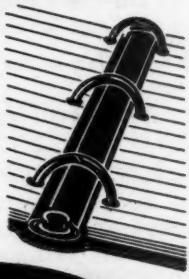

Pentrate is **widely** used on gauges, bearings and precision instruments for **increased performance** and **protection.** Remember there is **positively no size change** and nothing to chip, crack, craze, peel or rub off.

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ATTRACTIVE BLACK APPEARANCE
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Pentrate material shipped immediately from stock. No waiting — No priorities necessary.

Non-defense and semi-defense items such as ring binders, bicycles, washing machines and thousands of others find Pentrate readily accepted by the consumer.

We will gladly Pentrate samples of your product and return them promptly without charge.

Our FREE 18 page Pentrate booklet explains the process and describes equipment necessary — send for it today.

HEATBATH CORPORATION
SPRINGFIELD, MASSACHUSETTS, U.S.A.

THE QUESTION BOX

Los Angeles Branch

1. *How to prepare zinc base die cast prior to cadmium plating?*

Ans. Degrease, clean in mild cleaner and rinse in hot water then cold water, mild acid dip, rinse and plate.

2. *How to cadmium plate on magnesium?*

Ans. Treat metal same as plastic.

3. *How am I going to know when I have .0015 of gold on brass disc?*

Ans. One amp. hour will plate so much and without amp. hour meter will have to figure out it that way. Will have to guess at efficiency of the solution unless anodes are weighed.

4. *Anyone know of a nondestructive method for determining thickness of gold?*

No answer.

C. C. MCLAREN, *Secy.*

Toronto Branch

1. *What is the best way to remove carbonates from cyanide solutions?*

Ans. Use Calcium Sulphate or freeze out.

2. *What acid is used in the Bullard-Dunn pickling process?*

Ans. Sulphuric.

J. S. CAIRNS, *Secy.*

Chicago Branch

1. *How can embrittlement of steel caused by cyanide copper plating steel be removed, will the stripping of the copper relieve this embrittlement?*

Ans. The embrittlement can be relieved by heating for about 1 hour at 350° or 2 hours at 212°. It also depends on the type of steel, Low carbon steel does not embrittle as much as high carbon steel.

2. *Will 2 lbs. of zinc dust rather than 1 lb. of zinc dust to 100 gal. of zinc solution cause any harm, and what impurity will it remove?*

Ans. No harm will be caused by using 2 lbs. of zinc dust to 100 gal. of solution, it will remove lead impurities, which often cause a dark deposit in a zinc solution.

3. *Has anyone any experience with adding a wetting agent in a zinc solution to hold down gassing?*

Ans. One member stated that he uses about ½ lb. of Nacconal No. 18 to 100 gal. of solution and it does help to hold down gasses but the switch should be turned off before loading or unloading the tank.

4. *How do you remove the scale caused by annealing the furnace on copper stampings and bars to prepare these for hot dip tinning?*

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The Abstract Section

GEORGE WAGNER, *Chairman, Program and Educational Committee*

Electrodeposition of Nickel-Tungsten Alloys from an Acid Plating Bath. By M. L. HOLT and M. L. NIELSEN. *Trans. Electrochem. Soc.* **82,** (Preprint) 3 (1942). Small amounts (up to 16 g./1.) of sodium tungstate, $Na_2WO_4.2H_2O$, were added to a Watts nickel bath which contained enough excess sulfuric acid to avoid precipitation of the tungsten. The deposits were nickel-tungsten alloys, and became less metallic in appearance as more tungsten was added. The relationship between tungsten content and current density, pH, cathode efficiency, composition of deposit, and temperature of the bath are reported and discussed. Oxides appeared to be present in the deposits. The deposits may be more resistant to hydrochloric acid than pure nickel, but no commercial use is suggested.

ERNEST H. LYONS. JR,

Increasing the Throwing Power of the Chromium-Plating Baths. By N. D. BIRYUKOV and A. V. TOMIKHINA. *Korroziya i Borba s Nei* **6,** No. 2, 45 (1940). A bath containing CrO_3 and F- or SiF_6-- has a higher throwing power than the Cr bath containing SO_4--. At 77° F. and c.d. 45-75 amp./sq. ft., the Cr deposits are very bright and the throwing power is three times that of the SO_4 bath used at 122° F. and 280 amp./sq. ft. However, after 70 amp hrs./1.(280 amp. hrs./gal.) has passed through the F bath, the Cr deposit becomes dull and defective. The same happens to a bath containing H_2SiF_6 after 280 amp. hrs. The concentration of HF, KF, or H_2SiF_6 does not change with time. Filtering the baths after long use does not improve the quality of the Cr deposit. After oxidation CrIII = CrVI at a c.d. 110 amp. / sq. ft. the Cr deposits do not improve appreciably; dull areas persist. The F containing baths can be kept safely in tanks lined with an alloy of lead plus 1-15% antimony.

C. S. SHAPIRO, *Chemical Abstracts*

The Influence of Chromium Plating on the Toughness of Spring Steel. By A. L. LAVROV and A. P. TKACHEV. *Optiko-Mekhan. Prom.* **9,** No. 8, 1-2 (1939); *Chem. zentr.* **1940 I,** 3018. Electrolytic Cr. plating of small pieces of steel causes embrittlement and slightly increases the tensile strength. These effects are connected with the diffusion of hydrogen into the basis metal. The Cr coating makes it difficult to remove the hydrogen by heating. Very thin pieces (as pens) which must withstand bending and shock should not be Cr plated.

M. G. MOORE, *Chemical Abstracts*

Electroplating with Tungsten and Molybdenum. By P. P. BELYAEV and A. I. LIPOVETSKAYA. *Korroziya i Borba s Nei* **6,** No. 2, 47 (1940): *Chem. Abstracts* **36,** 3735 (1942). Adherent deposits of tungsten-nickel alloys were obtained from a bath containing $(NH_4)_2SO_4$ 150, NH_3 60, W as H_2WO_4 3 to 9, and Ni as $NiSO_4.7H_2O$ 1 to 3 g./1.; c.d. 465 amp./ sq. ft., temp. 167° F., platinum anodes. The plates were not corroded by sulfuric

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acid. Attempts to deposit tungsten-tin alloys and molybdenum (by method of Paul: MoO_2 dissolved in HCl) were unsuccessful.

ERNEST H. LYONS, JR.

ANNOUNCEMENT

The second International joint American Electroplaters' Society, Toronto-Buffalo-Rochester branches, educational session, dinner and dance, will take place at the Hotel General Brock, Niagara Falls, Canada, Saturday, October 24th, 1942. Education session from 2:00 o'clock to 6:00 o'clock, dinner-dance to follow.

Messrs. John Acheson, Joseph Ruff and John Q. Adams will preside. Mr. W. M. Phillips of the General Motors Corporation, will present "Copper Plating — Past, Present and Future." Mr. Arthur W. Logozzo of the Hartford Chrome Corporation, will discuss "Modern Aspects of Hard Chromium Plating." Ample time has been allowed for questions and discussion of these very important plating problems.

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Construction of Electroplating Apparatus out of Faolite Plastic. By L. M. ANCHAROV. *Korroziya i Borba s Nei* **6,** No. 3, 56-8 (1940). Faolite sheets were made into a barrel and a hood used over acid vats. The surfaces were then painted with bakelite lacquer inside and outside. The construction of the barrel is given in detail. It is a 6-sided prism, through the center of which passes a steel rod. All connections were made of copper; screws and other metal parts were carefully cemented to the faolite and covered with bakelite cement. C. S. SHAPIRO, *Chemical Abstracts.*

Corrosion-Resistant Coatings of a Lead-Antimony Alloy. By P. P. BELYAEV and O. B. KHALATOVA. *Korroziya i Borba s Nei* **6,** No. 2, 48-9 (1940); *Chem. Abstracts* **36,** 3734 (1942). Adherent bright gray lead-antimony films were deposited from stable baths prepared from potassium antimonyl tartrate, lead carbonate, tartaric acid and phenol sulfonic acid. The throwing power was high. The deposits have little resistance to corrosion. ERNEST H. LYONS, JR.

Zinc Plating from Alkaline Electrolytes. By N. T. KUDRYAVTSEV and A. A. NIKIFOROVA. *Korroziya i Borba s Nei* **6,** No. 2, 44-6 (1940); *Chem. Abstracts* **36,** 3734 (1942). Bright, dense zinc deposits were obtained in alkaline baths without cyanide by adding tin. Mercury and lead can be used, but are less effective; tin and lead together are good. Best results were obtained with Zn 0.25 **N**; KOH 1.6 **N**; Sn 0.25 g./1. Carbonate and sulfate are detrimental. Throwing power was somewhat lower than that of cyanide baths. ERNEST H. LYONS, JR.

An Electro-Thermal Method of Plating Protective Alloy Films. By P. P. BELYAEV and N. N. SEMINA. *Korroziya i Borba s Nei* **6,** No. 2, 48 (1940); *Chem. Abstracts* **36,** 3733 (1942). Steel plated with nickel and chromium was heated at 1650-1850° F. in a high vacuum; diffusion was deep and the plate resisted corrosion almost as well as 18-8 stainless steel. When heated 2-4 hrs. in CO_2 surface oxidation occurred. When heated in NH_3, the plate became brittle. Adhesion was improved by heating.
ERNEST H. LYONS, JR.

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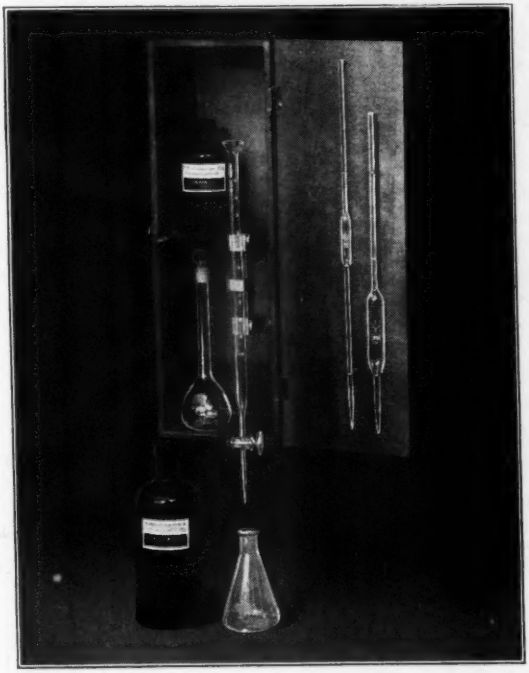

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Chromium Plating. By GEORGE DUBPERNELL. *Trans. Electrochemical Society* **80** (Preprint 24) (1941). Chromium plate is used as a thin, non-tarnishing, decorative metallic finish, usually over nickel plate; and, generally without intermediate coatings of other metals, as a heavy, hard coating, valuable in industrial uses for its resistance to heat, low coefficient of friction, resistance to wear, and resistance to corrosion and erosion. Discovered by C. C. Fink, the process used was introduced to industry in 1924; references are given to earlier history. The essence of the process is the use of a catalyst acid radial in proper ratio to chromic acid; Sulfates (usually as sulfuric acid) and fluorides, usually as fluosilicic acid, H_2SiF_6, are commonly used. The ratio of chromic acid, CrO_3, to sulfate, SO_4, should be about 100:1; limits are 50:1 and 250:1. "With a given set of conditions of bath temperature, current density, and chromic acid concentration, too small an amount of catalyst will result in either no plate or brown stains, and too high a catalyst content will result either in partial plating or none at all." The current efficiency is only 10-15%, but as current densities used are relatively high the rate of deposition is fair. About 4-10 volts are required. The throwing power is poor, but with proper catalyst ratio and some thought to racking and disposition in the bath, remarkably good results are achieved. Auxiliary anodes are sometimes used for deep hollows. Chromic acid supplies the metal ions to the bath, and as insoluble anodes are used, the chromic acid must be replenished regularly; it should have as little sulfate impurity as possible. Typical formulas are:

	"Concentrated" Bath	*"Dilute" Bath*
Chromic acid, CrO_3	400 g./1., 53 oz./gal.	250 g./1., 33 oz./gal.
Sulfate, SO_4	4 g./1., 0.53 oz./gal.	2.5 g./1., 0.33 oz./gal.

The dilute bath has a slightly higher current efficiency but lower conductivity than the concentrated bath, and is somewhat more sensitive in operation. The temperature and current density must be properly related to obtain bright deposits, although a wide range is possible. For example, the proper current densities for several temperatures of the dilute bath are:

Temperature	*Current Density*
104° F.	50-144 amp./sq. ft.
113° F.	75-216 amp./sq. ft.
113° F.	up to 288 amp./sq. ft.

Tables of plating speeds and cathode efficiencies are given for several temperatures and current densities in both baths. Trivalent chromium is constantly formed at the cathode and oxidized at the anode; an excess is usually the result of too large a cathode area and too small an anode area. Iron, copper, zinc, and other metal impurities increase the resistance of the bath. Filtering is seldom required, and pitting is rare. Complete procedures for bath analysis are given; for bath maintenance, physical methods may be used as well as chemical. The insoluble anodes are preferably made of lead; antimony or tin alloys with lead are more resistant than chemical lead, and therefore last longer. Iron anodes may be used, but lead to higher trivalent chromium contents and iron contamination. Tanks are of lead-lined steel, and antimony or tin lead alloys are preferred; an inner lining of acid-proof brick is highly recommended. The chromic acid spray given off

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in operation is a health hazard, and calls for special ventilation, described in references. Special insulating materials are used to cover racks and as "stop-offs". Small parts may be plated in wire mesh baskets which are described. Chromium plating in barrels using inside anodes has recently become successful. Conventional cleaning processes are satisfactory if thorough; a detailed procedure is given. When these are not feasible, a dry wipe by hand or on a wheel is often satisfactory, since the chromic acid bath has a limited cleaning power of its own; proper technique in "dry" cleaning is discussed. For "hard" chromium (heavy deposits) where good adhesion is especially important, an anodic etch in 50° Be. sulfuric acid at room temperature for 1 minute is recommended. High carbon steels and castings may readily be overpickled; sand-blasting is preferred. Zinc and zinc base die castings are generally nickel plated before chromium plating, and if the undercoat is adequate, offer no difficulty. For decorative purposes, coatings of 0.00001-0.00002″ are used; heavier plate suffer from hair-line cracking which reduces the corrosion resistance unless the plate is sufficiently heavy to subsequently cover the original cracks. Thin decorative plates may add to the corrosion resistance of nickel or copper-nickel coatings. The salt spray test is used as an accelerated corrosion test, and the ferroxyl test as a porosity test, although requiring much care. Average thickness is usually determined by stripping the coating from a known area, and analyzing for chromium. The decorative plate is too thin for microscopic or magnetic measurements; the spot test may be used to determine local thicknesses. The reported values for physical characteristics are discussed critically. The success of hard chromium plating is ascribed to the combination of hardness, corrosion resistance, and low coefficient of friction secured, since these properties may be obtained separately in other ways. A variety of applications of hard chromium plating is listed.

ERNEST H. LYONS, JR.

The Electrodeposition of Hard Nickel. By W. A. WESLEY and E. J. ROEHL. *Trans. Electrochem. Soc.* **82,** (Preprint 1) (1942). Hard nickel deposits were made for engineering purposes from a Macnaughton and Hothersoll bath modified by the addition of ammonium chloride to maintain anode corrosion. However, there were a number of rejects because: (1) deposits thicker than 0.02″ had a laminated structure which sometimes separated in machining; (2) the hardness could not be closely controlled; (3) a pronounced tendency to "tree"; (4) bath poorly buffered. The nickel chloride bath gave better results but the deposits tended to crack. The development of a more satisfactory bath is described; it consists of $NiSO_4.7H_2O$, 180 g./1.; NH_4Cl, 25 g./1.; H_3BO_3, 30 g./1. This bath is well-buffered, and easily controlled, affords precise control of hardness, avoids "rhythmic banding" or laminated deposits (which are discussed), and avoids "treeing". The cause of hardness of electro deposits is discussed. Adhesion values are given. The hardness of the deposits may be varied from 380-480 Vickers by regulating the conditions of plating. For example, a hardness of 400 Vickers can be obtained at 50 amp./sq. ft., 140° F., pH 5.6. Typical tensile properties are: ultimate strength, 157,000 lbs./sq. in., elongation, 6% in 2 in.

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The High Efficiency Cyanide Copper Bath. By H. L. BENNER and C. J. WERNLUND. *Trans. Electrochemical Society* **80,** (Paper 38) (1941). The deficiencies of the conventional cyanide copper bath and the rochelle copper bath are (1) slow plating rate, and (2) difficulty of control due to wide variations in anode and cathode efficiencies (30-70%). With anode and cathode efficiencies of about 100%, the high efficiency bath may be operated at higher current densities: hence the rate of plating is much greater, and control, although it must be close, is simpler. Smooth, bright deposits up to 0.002″ thick are possible. The principles to be followed are: (1) high concentration of sodium cuprous cyanide, $Na_2Cu(CN)_3$· (2) low free cyanide; (3) high sodium or potassium hydroxide; (4) high temperature; (5) suitable brightening and anti-pit agents; (6) agitation. The bath formula is:

	oz./gal.	*limits*
Copper cyanide, CuCN	16	12-20
Sodium cyanide, NaCN	18	13.5-22.5
Free cyanide corresponding to	0.5	0.5-1.5
Caustic soda	4	3-5
or caustic potash	5.6	4.2-7
Brightener	2	1.5-2.5
Anti-pit agent	0.2	0.15-0.25
Temperature	168-185°F.	
Cathode current density	10-100 amp./sq. ft.	
Anode current density	5-30 amp./sq. ft.	
Current efficiency	100% approx.	
E.M.F. still tanks	1-2.5 v.	
E.M.F. barrels	3-4 v.	
Cathode bar agitation	2-15 ft./min.	

The high current efficiency is essential for bright deposits. If the free cyanide exceeds 1.5 oz./gal., the cathode efficiency is decreased, and cyanide is decomposed, while the bright plating range is obtained at lower current densities. With the proper amount of free cyanide, cyanide decomposition is very slow. If the free cyanide is too low, excessive anode polarization and rough deposits may result. The anodes will also polarize if the anode current density exceeds 30 amp./sq. ft., while low current densities produce loose sludge which may make the deposits rough. Agitation, which is most important, extends the bright plating range and permits higher current densities. The temperature must exceed 168°F. Filtration, preferably continuous, is required. Contamination of the bath by lead and zinc should be avoided. Chromium is removed from the bath by sodium hydrosulfite. Organic contaminants are removed by adsorptive materials. Carbonate forms at the rate of approximately 0.067 oz./gal. in 24 hours; up to 8 oz./gal. can be tolerated, and on account of drag-out, it rarely exceeds this figure. Where analytical procedures other than standard are needed, these are given. Analysis should be supplemented by the use of the Hull cell. Electrolytic copper anodes are recommended. Since it does not gas at the cathode, the bath does not have the cleaning action of other cyanide baths; moreover, it tends to deposit copper by immersion on certain base metals. After standard cleaning pro-

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cedures, therefore, work should be given a "strike" in a conventional cyanide copper bath. After plating, thoroughly rinsing is required, especially for adhesion of nickel to be applied on the copper.

ERNEST H. LYONS, JR.

Protective Anticorrosive Films on Metal Products of Deeply Recessed Contour. By P. P. BELYAEV, *et. al.* *Korroziya i Borba s Nei* **6**, No. 2, 49-50. When plating does not cover recessed surface, phosphatization of steel is of little value unless coated with oils or lacquer, or passivated. Thus treatment of ordinary phosphatized steel with 1% $K_2Cr_2O_7$ increases the resistance considerably. Phosphatization of a zinc-plated surface gives high resistance to corrosion, especially when additional treatment with oils or lacquers is required. A piece was plated with .0008" of zinc, but there was no zinc in the recessed surface. After phosphatizing in a soln. of $Zn_3(PO_4)_2$, it stood 1000 hrs. in 3% salt solution and in water vapor at 64-68° F. without a trace of corrsoion. In zinc plating phosphatized surfaces to close the pores in the phosphate film, often zinc is not plated in recesses where the angle of curvature is very high. The corrosion resistance of the recessed surfaces was not more than 1/5 of that of the outside surfaces.

ERNEST H. LYONS, JR.

A Strange Phenomenon in Plating. By OLIVER P. WATTS. *Trans. Electrochem. Soc.* **82** (Preprint 2) (1942). Plating at 325-550 amp./sq. ft.; 186-204° F., in a nickel solution containing 10-40 g./1. (13-54 oz./gal.) $NiSO_4$ and 200-250 g./1. (27-33 oz./gal.) Na_2SO_4, gave good adherent deposits of nickel on the back of the cathode, but none on the front. About 22% of the current went to the back. Similar results were obtained at room temperature. In these solutions, which were relatively dilute in nickel, hydrogen was evolved rapidly at the face of the cathode, and it is thought that the alkaline film thereby produced precipitated all the nickel before it reached the cathode surface. At the back, the current density was lower, hydrogen was produced much more slowly, the film was not so alkaline, and nickel passed through it and plated. The addition of ammonium sulfate, sodium citrate, aluminum sulfate, or boric acid, which will prevent the formation of an extremely alkaline film by buffer action (ammonium salts will also prevent the precipitation of nickel in alkali) produced normal plating on front and back. Back-plating was also obtained with cobalt and iron, but experiments with tin, zinc, and copper were unsuccessful. In the presence of magnesium sulfate, the upper limit of nickel content for back-plating is lower than when sodium sulfate is used, corresponding to the relative alkalinity of the cathode film. It does not appear that the effect is of use in producing more uniform plates, but it may have some application in studying the effects of various additions to the cathode film.

ERNEST H. LYONS, JR.

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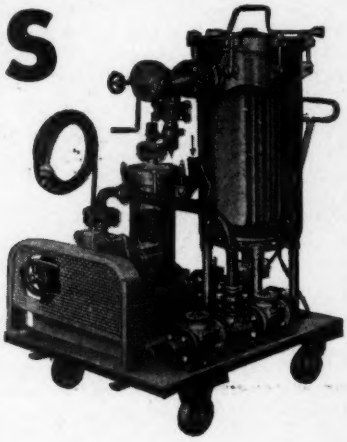

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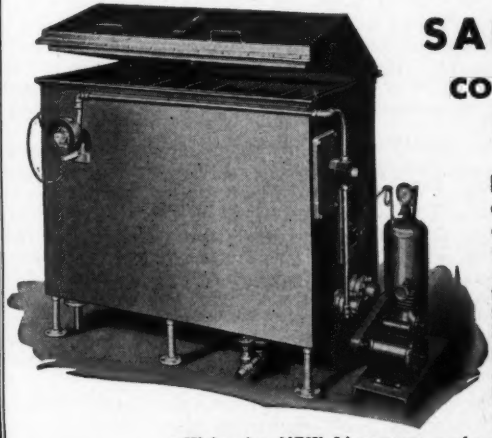

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Interestingly told in "INDIUM NEWS" Vol. 1, Number 1.

FORMAX ISSUE 3 NEW CATALOGUES

Now ready for distribution three new catalogues covering various types of polishing and buffing compounds and buffing wheels available.

UNITED CHROMIUM ISSUE NEW BOOKLET ON UNICHROME ALKALINE COPPER PLATING PROCESS

Informative 6 page leaflet describes this process. Particularly valuable in deep-drawing of steel parts, where ductile, adherent coating of copper is required to act as lubricant between work and drawing dies. Leaflet now ready for distribution.

FROTH FLOTATION PROCESS NOW RECOVERS VITAL METALS

Du Pont has developed new chemicals to be used in the froth flotation process which are recovering vital metals such as copper, zinc, lead, nickel, tungsten, etc. from low grade deposits.

Chemicals attach themselves selectively to the grains of valuable minerals, and air bubbles lift them to the surface. Precious minerals are skimmed off surface. Subsequent smelting provide metals that go into war implements.

Hector Sez . . .

The fall season's meeting of Detroit Branch certainly started with a "bang"! At least the sound tubes of the movie projector burned out and caused last-minute changes in the program. The movie then had to be shown as the last part of the program, instead of at first. Joe Hoefer, the Program Chairman, was flying around like the proverbial "chicken with its head off" to keep the meeting moving.

The Acting Secretary, Wright Wilson, didn't help Joe any on getting started, as he held up the meeting fifteen minutes to sign up a new application.

The promotion men for the Electrochemical Society, Gus Soderberg and Charley Eldridge, were flitting hither and yon, extolling the virtues of the coming meeting in Detroit on October 8th, 9th and 10th. Hector saw the scheduled program and agrees with Gus and Charley that there are papers of interest to all electroplaters, especially on Friday and Saturday. I understand all A.E.S. members are invited, even Hector!

The Detriot Branch Secretary, James Malone, is ill and Wright Wilson, an ex-sec, is taking over to pinch-hit for Jim until he feels better. All the branch members hope Jim recovers and attends the meetings as soon as possible.

Walter Pinner, in his "One Man's Opinion" of the Grand Rapids A.E.S. Convention, told the members of the good convention they missed by not attending. Of course, the Detroit members who attended knew Grand Rapids put on a good convention, but we wanted Walter to tell about it anyway.

Joe Pawlik told us some facts about Stopping-off Carburizing that he had learned the hard way. Hector didn't see any blistered hands, but took Joe's word for it that he had done the work himself!

SPEED UP WAR PRODUCTION

BY USING

LASALCO

ANODIZING, PLATING, or FINISHING EQUIPMENT

Lasalco equipment has always been made with one primary purpose in the minds of the engineers. That is — KEEP IT SIMPLE. That's important to the users of these machines because it does several things:

Gives you a machine with longer life because there are fewer parts. More rugged construction.

Enables the machine to withstand longer periods of sustained high-speed production without shutdowns.

Reduces maintenance costs and operating costs. Simplicity of design makes the equipment easier to control and operate.

You can find out more about the **complete line** of Lasalco equipment and supplies by calling in a Lasalco Engineer. He is a practical man who knows plating and finishing work. He knows how to lick a problem, do it fast, and get it done **right** the first time. Call him in for a consultation.

LASALCO, INC.

2818-38 LaSalle Street, St. Louis, Missouri

MEMBERSHIP REPORT

MAURICE R. CALDWELL, *Chairman, Membership Committee*

To October 1, 1942

APPLICATIONS

Detroit Branch

Herbert E. Head, 5547 Fairview, Detroit, Michigan Active

Hartford Branch

Fred Hartman

Montreal Branch

Max Albert Vogel, Union Screen Plate Co. of Canada, Ltd., Lennoxville, Quebec Associate

San Francisco Branch

John Mackesy, 1709 Oak St., San Francisco Associate

Waterbury Branch

John H. Ryan, 858 Main Street, Watertown, Conn. Associate

Lancaster Branch

Arthur J. Conner, 1826 Hooly St., Harrisburg, Pa. Associate

ELECTIONS

Bridgeport Branch

Carleton Harry Deuter, 223 Washington Ave., Bridgeport, Conn. Associate
Eugene Paul Schimmel, 94 Henry St., East Port Chester, Conn. Associate

Detroit Branch

W. J. Chambers, 13199 Northlawn, Detroit, Michigan Active
Kenneth Wall, 7537 Linwood, Detroit, Michigan Active

Newark Branch

Charles H. Muller, 371 Vally Rd., West Orange, N. J. Active
Vernon G. Frey, 49 Lincoln Ave., Livingston, N. J. Active
Frederick J. Kirkman, 29 Vreeland Ave., Hawthorne, N. J. Associate
Herbert J. Mueller Active
Ellwood I. Neuer, 38 Henry St., Iselin, N. J. Associate
Harvey K. Hunt, 15 Sutphin Ave., Matawan, N. J. Associate
William J. Jancik, 203 Green St., Boonton, N. J. Associate
Harold L. Cobb, 250 Rockway Ave., Booton, N. J. Associate
Eugene Duchin, 445 Pennington St., Elizabeth, N. J. Associate
H. V. Mckay, Massy Harris Pty., Ltd. Australia

TRANSFERS

George C. Mounty, from Lancaster to Philadelphia
C. H. Stoddard, from Chicago to Milwaukee
H. C. Luechauer from Dayton to Cincinnati

SUSPENSIONS

Harry Garside, Los Angeles Branch
Mabry C. Courtney, Los Angeles Branch

MEMBERSHIP CAMPAIGN REPORT

BRANCH	May 1, 1942	Change in Membership	Percent Change
Cleveland	81	+16	+19.8
Indianapolis	48	+6	+12.5
Cincinnati	42	+4	+ 9.5
Syracuse	31	+2	+ 6.5
Newark	156	+10	+ 6.
Bridgeport	80	+1	+ 5.
Pittsburgh	52	+2	+ 3.8
San Francisco	46	+1	+ 2.2
Chicago	258	+5	+ 2.
Buffalo	55	+1	+ 1.8
Balt.-Washington	82	+1	+ 1.2
Detroit	277	+3	+ 1.
Waterbury	97	+1	+ 1.
Philadelphia	142	+1	+ .7
Binghamton	16	0	0
Boston	118	0	0
Lancaster	44	0	0
New Haven	105	0	0
Prov.-Attleboro	49	0	0
Rochester	80	0	0
St. Louis	82	0	0
Toledo	46	0	0
Toronto	87	0	0
Grand Rapids	87	—1	— 1.1
Montreal	44	—½	— 1.1
Dayton	99	—2	— 2.
Los Angeles	128	—3	— 2.3
New York	139	—4½	— 3.
Springfield	72	—2	— 3.
Milwaukee	97	—4	— 4.
Hartford	67	—4	— 6 0
Anderson	38	—3	— 7.9

NOTE: Honorary members are included with each Branch.

MEMBERSHIP — May 1st, 1942 = 2845
MEMBERSHIP — Oct. 1st, 1942 = 2878
GAIN IN MEMBERSHIP 33
GAIN = 1.16%

DEATHS

S. E. Hedden, Pittsburgh Branch
Elwood H. Mead, Detroit Branch
H. A. Chapman, Cincinnati Branch
M. A. Mechley, Cincinnati Branch

REINSTATEMENT

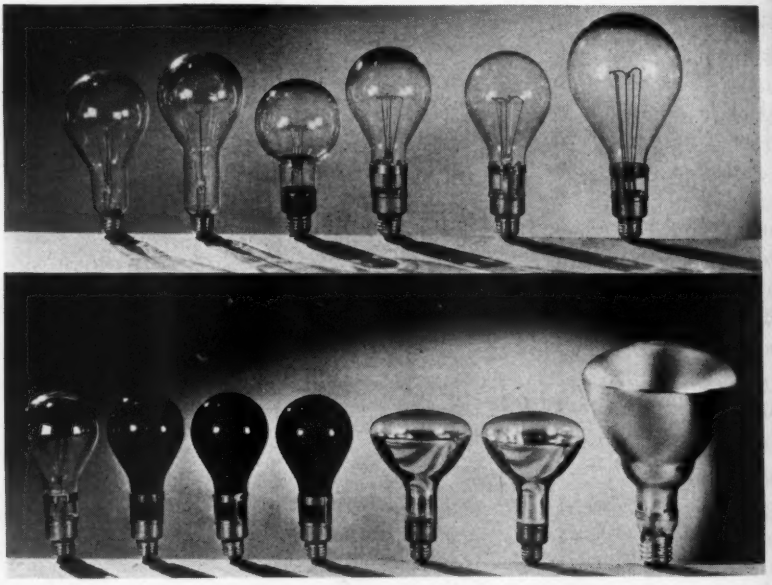
H. Bruce, 2204 Clement St., Alameda, Calif., San Francisco Branch Active
H. Bruce, San Francisco Branch
John Deamico, Bridgeport Branch

RESIGNATION

Richard E. Feild Lancaster Branch

INFRA-RED SAVES TIME

Advantages claimed for infra-red are speed, ease of operation, and economy. Savings in time, in many instances, are said to be sensational, with users reporting up to 95% faster baking and drying time than with older baking systems. Initial investment is low because infra-red equipment is relatively inexpensive and is quickly and easily installed. Operating cost is reported lower since full heat operation is started instantly with no fuel or time lost in



preheating. Infra-red is apparently as easy to use as regular light bulbs, as a flip of the switch brings the heat in full force immediately. Since lamp installations are lightweight, they can easily be moved, and since they are more compact, they usually occupy much less floor space than conventional types of baking drying and heat-treating methods. The entire subject is covered in new literature being issued by the Wabash Appliance Corp., 345 Carroll Street, Brooklyn, N. Y.